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Columbus Flood Report The first of the reports on flood-prevention measures in the territory seriously affected last March has now been rendered. Messrs. Alvord & Burdick recommend for Columbus a scheme costing about $11,000,000, which expenditure they point out is warranted from financial considerations alone, since the annual flood damage for the last fifteen years has been not less than $540,000 per annum. The engineers find that a maximum flood flow of 150,000 sec.-ft. should be provided for and that channels or flood-relief measures should be so proportioned that one-half more than the computed flow can be cared for before a great calamity or disaster similar to that of last March would occur. Consideration is worth while also, they believe, of projects to care for 200,000 sec.-ft., for which volume a combination of reservoirs and new channels in the city is the cheaper. For flows of 150,000 sec.-ft. a channel project alone is of lower cost. Reservoirs, of course, will benefit other communities in the valley, and if they are willing to share in the expense the projects in which reservoirs are combined with channels will have an advantage over all others. While the report itself will be read with care by engineers, it will be still more interesting when it can be compared with the reports in preparation for Dayton and other Ohio cities. The important point now, however, is that one of the recommended plans be pushed rapidly in order that construction may be begun. At best, reasonable time will be needed to sound other communities which might be interested in joint financing of a reservoir project. But on the other hand, the matter should not be allowed to drag. Remembering that what is everybody's business is nobody's business, responsibility for pushing the matter to a conclusion should be definitely fixed.

Hadley a New Haven Director The election of President Hadley of Yale University as a director of the New Haven road has unfortunately received less public notice than it deserved. The public served by that company is to be congratulated upon his entrance to the board at a time when he can have a voice in the protective reconstruction movement which confronts the new management. One of the railroad conditions with which the public finds fault is the perpetuity in office of the interlocking banking and railroad representatives who dominate most of our boards. As a matter of fact, the constructive criticism which is needed in large corporate enterprises may come more effectively from an outside student of policies and results than from one who has sympathetically viewed the operations of the property from within. President Hadley represents a large security interest in the road, but his pre-eminent qualifications are his ability as an economist and his high public standing. As chairman of the Railroad Securities Commission appointed by President Taft he rendered invaluable public service to both the nation and the railroad corporate world. His opportunity as a New Haven director will be less conspicuous, but it is just as certainly a public service. The task of re-creating a favorable, even a tolerant, public sentiment is a serious one, and the directors and officials of the New Haven will have to do what they can with it, no matter how much injustice they meet in the beginning. The election of an individual member of so large and powerful a board as that of the New Haven will not invest the road immediately with a public regard which it has failed to win and hold, but the step which this company has taken is one that other railroads will do well to follow, if they can find men in their localities of somewhat similar standing who are willing to take office.

Publicity and Engineering Attention has frequently been called in this journal to the value of publicity in originating and carrying out engineering work. One of the surest ways of securing popular support for bond issues for engineering work is to put the facts clearly before the voters and appeal to their good judgment. Often conditions that must be rectified are so bad that they give all the publicity that is needed. A dangerous or bad-tasting water supply is a sufficient argument for the development of a new source or the construction of a filter plant. Impassable streets do not need to have their shortcomings preached to the populace. In transient matters, however, it may be necessary to institute a publicity campaign to remind the people of dangerous or insanitary conditions, which grow less important in their minds as time passes. This is quite likely to be the case with reference to flood-protection measures. Immediately after the heavy floods of last spring the city of Olean, N. Y., which had suffered considerable damage, retained Mr. George C. Diehl to make a study of conditions and to recommend abatement and protection measures. His report was rendered some time ago. Realizing the danger of apathy, the Chamber of Commerce has taken up the matter and is conducting a vigorous educational campaign by means of circulars and illustrated lectures, all under the direction of a trained publicity man. The reasons for the flood and the methods of abatement are being explained. It is hoped in this way to work up sentiment in favor of the appropriations which will be necessary to carry on the work. The same idea is being applied in a somewhat different way in Dayton, where a demand was found for information as to the progress of the flood-prevention studies. Accordingly a competent publicity man—an engineer with newspaper training—was engaged to put the data in shape for distribution to the newspapers. Doubtless his functions can well be widened when the report is finally rendered, though in a city so badly hit as Dayton was there is less likelihood of apathy than in places where the damage was less. The plan is well worth while for engineers to bear in mind.

The Trainmen and Economy During the arbitration of the higher-wage demands of the Eastern conductors and trainmen it was brought out that if the men's demands were granted one conductor now getting $3.63 for a ten-hour run would receive $9.69 when three engines were used. At the suggestion of counsel the witness blandly admitted that the men did not expect that much money, but that they sought "to make the practice of using two or more engines prohibitive." In other words, the brotherhoods not only want to fix their pay but decide, too, upon the methods of operating the railroads. For many years past the best efforts of civil and mechanical engineers have been applied to the reduction of operating ratios by enlarging car and train units. A part of the economy effected is frankly a reduction in the total wages by reducing the number of trainmen. It has long been supposed that industries were justified in the adoption of labor-saving machinery, but it seems that railroads are to be excluded from this privilege. If this be true, money spent on grade reduction may simply be thrown away, because the brotherhoods will not permit the lengthening of trains that would be mechanically possible. In its remarkable series of studies whereby the Baltimore & Ohio was able to make such increases in train lengths the management seems to have made the fatal blunder of failing to get the consent of its employees, and we may expect it to go back to its short, inefficient trains, and offer its new dynamometer car for sale as junk. It will be interesting in the report of the arbitrators to note their decision on this point.

Tests for Asphalt Cement The article on page 345 of this issue will not meet with the approval of a great many specialists in asphalt construction. They contend that tests for specific gravity, fixed carbon, paraffine, sulphur, etc., which Mr. Howard believes to be irrational, since they do not indicate qualities required in paving work, are necessary in order to differentiate types of materials which have proved successful in practice. Even the most ardent advocates of these chemical and other tests to which Mr. Howard objects cannot deny, however, that the clauses specifying these tests have been manipulated for dishonest purposes—to prevent competition on merit alone. The way to reach conclusions in which all can agree is not to suppress one side or the other, but to present both, and thus shed light upon the subject. With this object in view, Mr. Howard's paper is presented.

On the Other Man's Shoulders It is astonishing to see how long a time is required to spread knowledge of proper designs and to impress on engineers the futility of again experimenting (?) with types of construction which careful observation has shown to be unsatisfactory. This is strikingly brought out by the methods being pursued in many parts of the country in the construction of concrete and of brick roads. In Wayne County, Michigan, in the one case, and in the city of Cleveland and Cuyahoga County, in the other, are found probably the best types of these roads. They have experimented with different proportions, fillers, expansion joints, etc., and have proved to the satisfaction of those with the widest experience that certain designs and details are inferior to others. With the publicity given to the work in these two sections one would expect that their experience would be widely applied. While probably true to a considerable degree, numerous cases could be cited of the utter neglect of what Wayne County and Cleveland have learned. It is the part of wisdom, and a condition for progress, to stand on the shoulders of our predecessors. There are plenty of unsolved problems in both concrete and brick road construction to engage the attention of those who want to experiment. The experiments, however, should be in the line of advance and not upon methods already found wanting.

Concrete Roads of Wayne County

Nearly five years ago the first concrete road in Wayne County, Michigan, was built near the town of Wayne. Since then the mileage has been increased year by year, and with it the fame of the system itself. Next week it will be subjected to a scrutiny hitherto unknown in its history, for the cohorts attending the Road Congress will descend upon it, examine it both in a friendly and in an inimical spirit, and thresh out its merits and demerits in the corridors of convention hall and hotel. Even with this program in prospect it is not amiss to call attention to some of the features of the Wayne County work, for many engineers will be prevented by distance and other causes from participating in the inspection and the subsequent discussion. A fuller account of the system and methods will be found elsewhere in this issue.

While the original road is still in excellent condition and shows the typical mosaic surface characteristic of even wear, errors have been made in experimenting with leaner mixes, kinds of joints and numbers of courses. Nevertheless, one readily sees on inspection that the work is in the hands of men who are advancing the art of roadbuilding at a rapid pace, avoiding the repetition of mistakes as soon as they are apparent. It is to their credit that not a single slab put down by the commissioners has been removed.

Concrete in roads undoubtedly gets harder usage than in most other forms of concrete construction. Each surface stone is hammered continually by the traffic passing over it, while the structure as a whole is subjected to considerable stress in carrying loads from its surface to the foundation. The impact on the surface stones is severe, while unevenness of surface and irregularity at expansion joints increase the shocks to which the pavement is subjected. In consequence, the Wayne County officials use a rich mixture, 1:1½:3. This is the nominal mixture, but actually the sand is apportioned to more than fill the voids between the stone. An extra effort is exerted to get the surface true, especially at the expansion joints, where troweling away from the iron strips has given much better results than troweling toward the strips. Even brief consideration of the difficulties of the work will convince one that it requires the best of workmanship, a richer concrete, better inspection and supervision, more careful holding to grades and protection from drying out than almost any other kind of concrete construction. These things seem to have been well appreciated in Wayne County.

Maintenance, too, has been put on a sound basis. The concrete roads receive careful attention the season following construction in the way of tar coating on and in all expansion joints and accidental cracks, most of which develop within that period. So well do the men with the tar pots do their work that it is not uncommon to find pits caused by a single 1 or 2-in. loosened stone covered with a splotch of tar. This splotch is eventually ironed out to a formidable looking patch of 12 in. or more in diameter. Larger holes where some raveling has taken place due to insufficiency of mortar are cleaned thoroughly before applying the gravel and tar.

Armored expansion joints are put in at an arbitrary interval of 25 ft. This figure corresponds very well with observations recently made by a representative of the Engineering Record on a California concrete road, 4 in. thick and 15 ft. wide, which was to be covered with oil. In a distance of 1120 ft. the cracks appearing within a month of the time of laying averaged 28 ft. apart, but varied from 6 to 75 ft.

Finally a word is needed on the general conduct of the work. It was found at an early stage that the contract system could not, or at least did not, give the required results, so the day-labor method has been in vogue. Expending annually $600,000, employing, housing and feeding as many as 1000 men per month, purchasing and unloading 1200 cars of material per month and keeping $100,000 worth of equipment in trim would be considered in a private business a sufficient reason for the employment of a corps of high-salaried officers, a retinue of clerks and bookkeepers, to say nothing of a force of engineers, inspectors and foremen. When it is learned that the paltry sum of $6225 was expended last year for supervision it is readily apparent why the Wayne County system has been studied with more than usual profit by communities in other sections about to enter on a roadbuilding era.

Seeing Is Believing

The value of the educational propaganda carried on by manufacturers of engineering materials and equipment has frequently been commented upon in these columns. Through the advertising pages of technical periodicals and through pamphlets the uses of equipment have been taught and much good has been accomplished in inculcating proper ideas as to the utilization of new and old materials. These publicity methods, however, have limitations, particularly when it is desired to convince engineers of the lasting qualities of a material. Photographs and descriptions, unless very complete and from a variety of sources, fail to carry the conviction necessary to secure the adoption of one material in the face of strong and worthy competitors. "Seeing is believing" applies as well to engineers as to the children who use this expression. It is for this reason that the annual meeting of the National Association of Paving Brick Manufacturers in Cleveland last week was turned into an inspection tour for city engineers and highway officials and that cement companies have been taking parties to see the concrete roads in Wayne County, Michigan. They believed that they had something to show that the "seeing" would carry conviction. At Cleveland there was no hesitancy in showing brick pavements that were not satisfactory; but even these carried lessons that may have been as beneficial as the impression made by the better roads. As to the inspection of highways around Detroit, it is urged that they have not yet proved a success, and it will be interesting to note whether inspection parties will be taken to view them when they are ten rather than five years old. Without going into controversies as to the merits of different types of pavement, it may be admitted that inspection trips may not always be honest. Nevertheless, they open to the manufacturer an opportunity to convince the engineer as to the merits of the products that can stand the test of close scrutiny. It is self-evident, of course, that there are limits to the entertainment which an engineer can accept. While he might well accept hospitality at the point of inspection, his independent and impartial position demands that he decline entertainment in the form of full expenses for a long railroad trip. Furthermore, in making the inspection his wishes must prevail, for fear his hosts may show him only the good and prevent him from seeing the bad. First and last he is a professional man and must be guided by his professional ethics. He cannot accept any courtesy or entertainment that will prevent him from deciding against the particular material should his judgment demand it.

Permanent and Impermanent Elements of Roads

Road construction as a practical art is at present in a decidedly unsettled state. Old conditions have been overturned; new conditions are changing rapidly. New materials and methods are continually being offered, while inventors and makers of heavy vehicles outstrip roadbuilders. Swift-moving, motor-propelled pneumatic tires exert quite different destructive tendencies upon road surfaces from those exerted by steel tires and horses traveling at slower speeds. Ten-ton, and heavier, loads require more substantial support than the lighter loads of bygone days. But in some places, where roads have been intelligently adapted to their traffic and separate ways provided for motors and horses, experience is showing that the older kind of traffic sometimes causes the larger maintenance bills. In other words, the automobile is not so destructive to roads as commonly reputed, given roads suitably made.

In much of the modern study of roads attention has been too exclusively concentrated on the surfacing. In order to please as many persons as possible with the least first cost endeavors have too often been made to cover many miles of road with some sort of pavement that would present a good appearance, and make convincing "before-and-after" photographs to exhibit to "constituents." Recently, at the close of such an exhibit contrasting the profound ruts and sloughs "before" with the smooth new surface, an engineer suggested that if the pictures were preserved five years they might appropriately be shown in reverse order to point another moral. Frequently such pavements have been laid upon foundations inadequate for the traffic and insufficiently drained to prevent the destructive effects of water and frost. Some of them have been built with the proceeds of long-term bonds, and in such cases communities and States are now realizing the gravity of the blunder, finding their money gone—and their roads, too. More conservative policies would not immediately produce so many miles of road with a given appropriation, but would result in ultimate economy.

Better highway construction must begin with careful regard for location and grades. Foundations must be well drained and of sufficient depth and solidity to sustain heavy loads without injury. Embankments must be built of suitable materials and thoroughly consolidated.

The width of pavement needs careful consideration. If too narrow, it soon begins to break down along the edges, its life being thus materially shortened. Safety, too, demands greater width for the passing of high-speed vehicles than was necessary with slow-moving vehicles, while serious accidents have resulted from one or two wheels of an automobile sinking into a soft road shoulder while the other wheels were on the pavement.

In view of these considerations it seems fitting to differentiate the parts of the highway structure as to their permanence. For a well-located road the ground structure—the cuts, fills, culverts, masonry bridges, in fact everything below sub-grade, together with a high-class concrete foundation for the pavement—may justly be considered as permanent. Consequently for these portions of the road money might properly be raised on long-term bonds. Very few kinds of pavement when well laid and cared for are proving that twenty to thirty-year bonds may be justifiable to defray their cost. Others should be paid for only from current cash, as they need renewal in from one to five years. There are intermediate grades of surfacing for some of which short-term bonds may be permissible, but such bonds are often not very attractive to bond buyers.

Careful consideration of these principles would go far toward creating a saner policy in road expenditures and save the "good-roads" movement from the discouragement that would be sure to result from a continuance of erroneous financial and construction policies.

Principles versus Practice in the Teaching of Engineering

The increasing influence of the specialist in modern professional life is being felt in institutions of higher engineering education to a degree which warrants a note of warning against a possible neglect of fundamental principles in the intense pursuit of current practice which is found in so many classrooms as the natural result of employing the so-called "laboratory method" in up-to-date instruction. Interest in concrete problems and apparatus naturally is felt by the student of engineering. The majority of undergraduates prefer to be taken through a large plant on an inspection trip or to be allowed to perform minor tasks in connection with some test or construction work of commercial value than to "bone down" to principles and mathematics bearing upon the theoretical side of present-day practice. Abstract problems appeal only to the minority in every walk of life. Just as the present civilization cannot be correctly interpreted without a reasonable knowledge of the past, so must the most enduring progress in the engineering profession rise from the great fundamental principles which are virtually fixed in comparison with the ephemeral practice of the moment. Little danger exists that practice will be ignored in schools responsive to the spirit of the laboratory, but there is some doubt whether the fascination of studying the latest vogue in different engineering specialties may not at times obscure to both teachers and students the profound importance of fundamentals.

Experimentation without thorough grounding in principles may uncover valuable finds now and then, but it will not further the most efficient work. The limitations of current practice are very much greater than most people realize, and many a young engineer has learned this to his sorrow when he has tried to meet new conditions with handbook formulæ of restricted scope. It has often happened that results of enduring value have come about through the work of so-called theorists upon empirical data and designs which alone have failed to solve the problem in hand—and which probably never would have solved it without the help of the expert in principles. This point was illustrated by Dr. James Douglas in his commencement address last spring before the Colorado School of Mines, upon the "Larger Importance of Principles than Practice in Technical Education." He showed that the effect of the injection of air into molten metal was perfectly understood before Bessemer brought mechanical ingenuity as well as chemical science to bear upon the solution of the pneumatic method. The practicability of extracting the carbon to the exact point at which pig iron is converted into steel proved to be so difficult that the Bessemer process would probably have had a limited range of usefulness had not the suggestion of another chemist been adopted—to oxidize all the carbon, then readd to the charge the specific amount of carbide of manganese with a known quantity of carbon to recarbonize the iron, while the manganese absorbed any dissolved oxide of iron. The whole success of this momentous improvement, which was no discovery at all, depended upon the application of known facts to meet certain practical conditions.

Insufficient knowledge of principles spells disaster for the engineer who attempts to rely upon current practice alone in contributing to the real advancement of the industry. In the electrical field, new methods and applications are coming so rapidly into use that the practitioner without a deep-rooted understanding of the laws which underly it finds himself hard put to keep in sight of the "tail-end" of progress; he loses time in grasping the significance of specific developments and undertakes original and responsible work at no small risk to his reputation. Without a knowledge of stresses and strains, he designs a steel tower transmission line at his peril; without keen comprehension of the phenomena of inductance he locates and spaces his conductors with the chance that the resulting voltage drop will be perhaps 30 per cent greater than is warranted; and without an understanding of all the complex electrical considerations influencing the power-factor and the load-factor, he copies his neighbor's practice at the risk of financial ruin. All the construction drawings of concrete reinforcement that can be crammed into a single desk after being brought home from other jobs are of little value if the designer confronted with a new set of conditions is weak on figuring his own stresses. In the field of power-plant design the engineering executive whose word is final in the selection of machinery may not be familiar with all the latest practical appliances for corralling the elusive heat unit between the furnace and the feed-water heater, but he must possess a knowledge of the fundamental laws of steam engineering if he is to be anything beyond a puppet in the hands of his subordinate officers.

This side of the subject of professional education is apt to be overlooked by the young fellow whose enthusiasm is rightly stimulated by frequent observation of the triumphs of the men in the field, but he will realize it soon enough if he associates with less well-grounded workers after graduation. It is surprising how flexibly one can meet new demands year after year, given sound and extensive preliminary training in main principles, supplemented by constant hard work in their varied application. There is no need to discuss here the relative benefits of classroom and laboratory instruction or the comparative value of machine design and machine testing; for all these phases of education have their place in a well-planned curriculum. But in the last analysis, manual skill belongs to the artisan rather than to the engineer, and a knowledge of principles is of more value to the latter than familiarity with engineering equipment. Even the engineer's acceptance of principles, outside of mathematics, should be held as open to modification, but in the main the fundamental laws of physics and chemistry should be appreciated in all their inclusiveness as the primary working tools of the profession, and as such should receive the first consideration of instructors, whose lives are largely devoted to sending properly qualified recruits into the ranks of modern industry.

Grade-Crossing Elimination

In discussing grade-crossing elimination in its report for 1912 the New Jersey Board of Public Utility Commissioners expresses itself in favor of the division of the cost of such work between the public and the railroads. Nevertheless, the Legislature, subsequent to the preparation of the report, and knowing that the board was opposed to the policy, saddled the entire expense on the railroads. Of course, the board has no alternative now but to enforce the law; its conviction, however, should insure the administration of the statute so as to do as little injustice to the railroads as possible.

On account of the board's attitude it is worth noting its general conclusions on the subject. The report points out that a rational solution of the problem requires an appreciation of the immeasurable difference in hazard between grade crossings that gridiron a populous city and those in open country. The board classifies crossings according to the elements of danger. It cites the following conditions as dangerous: Two or more tracks on a sharp curve with obstructions close to the right-of-way lines, and light vehicular traffic; diagonal crossings where an approaching train can be seen from a vehicle only by looking backward; obstructed view to the right-of-way line at all corners; crossings where travel is heavy, with only a fair view of trains in either direction; much-used crossings where trains standing at a station obstruct the crossing, and, finally, crossings with four or more tracks of which the middle tracks are used for high-speed trains. Obviously certain combinations of these conditions greatly increase the danger.

But even in the cases cited expense is not a negligible item. The public often demands safety measures at whatever cost, but practically no more money can be spent than can be raised. The commissioners point out that there are other elements of danger than grade crossings in railroad operation. They concede that it is the duty of the railroads by good management, the installation of mechanical devices, proper signal systems and strict enforcement of rules to eliminate them as far as practicable, and they consider it the duty of the State authorities to require these things if they are not voluntarily provided. They appreciate, however, that there is a limit to such requirements which cannot be passed if the railroad company is to continue to supply service. It is difficult now for some smaller roads to maintain tracks, bridges and equipment in condition for safe operation; to compel them to eliminate grade crossings would mean bankruptcy. Grade-crossing elimination is very expensive, and the need in individual cases should be carefully weighed against other safety measures which can be provided for the same expenditure. Finally, it is worth while to remember that in practically all cases accidents at grade crossings are due to the negligence of at least one of the victims, which is not true with other classes of railroad accidents to the prevention of which the grade-crossing money might be applied.

Wayne County Concrete Roads Serve Farmer and Motor Driver

Hard Roads in Wayne County, Michigan

Eighty Miles of Concrete Roads Leading Out of Detroit Have Been Built in the Last Five Years, Principally by the Day-Labor Method

One horse instead of two to a loaded truck-gardener's wagon, motor trucks for milk collections and a 30 per cent saving in time for the farmer's trip to town are a few of the ways in which the man who lives along the hard roads of Wayne County, Michigan, says he is benefited.

Wayne County's principal city, Detroit, is situated at the center of one side of the international boundary, the Detroit River flowing north and west of the Canadian city of Windsor. Farmers' produce, therefore, must be brought in from three sides only, and the 40,000 owned automobiles and other urban vehicles concentrate traffic on main arteries laid out by the founders of the city in ten radial trunk roads. With the rapidly increasing manufacture of power-driven vehicles, which scatter a water-bound macadam road over the fields, there developed an insistent request for numerous additions to the system and a panacea to prevent the maintenance charges from mounting higher and higher.

Topographically Wayne County is comparatively flat, with a clayey soil interspersed with a few sandy stretches. In the spring unimproved roads are wellnigh impassable.

Michigan Road Laws

Michigan's laws relating to roads include provisions for State aid or State reward of $500 per mile for gravel roads and $1,000 per mile for concrete and macadam roads, given to such counties as adopt the county-road law, elect supervisors and improve such roads as the county as a unit is willing to take over.

Money comes from two other sources—from the sale of fifteen-year county-road bonds, of which $2,000,000 have been authorized in Wayne County; and from a county-road tax levied by the Board of Supervisors. The latter sum cannot exceed 50 cents per $1,000 of assessed valuation. For 1910 and 1911 the county-tax levies were 48 and 6 cents per $1,000 respectively. No tax from this source was levied in 1912, as more money from the sale of bonds was available than could be spent economically.

In addition to the ten radial roads which focus on the city hall in Detroit, as shown in the accompanying drawing, there are secondary roads connecting small centers of population and tributary roads connecting the trunk lines. Of the 1375 total mileage in the county outside of the cities and villages only 157 miles are under the supervision of the county highway commission. Approximately 120 miles are improved, and of these 80 miles are of concrete.

Choice of road material in Wayne County outside of the cities for the last few years has fallen on concrete. Lack of proper clay makes the cost of a brick road prohibitive, according to the commission, and various other materials tried were unsatisfactory, particularly from the maintenance standpoint. Also, the original costs of road per square yard depend quite largely on local conditions, inasmuch as hauling charges enter so largely into the total cost. The range is from $1.04 for a stretch near Wayne five years ago, where the railroad was close at hand, to $1.71 per square yard on Jefferson Avenue, 9 miles from a railroad, raising the price of materials 85 cents per yard. An average of $1.50 per yard is given for first cost.

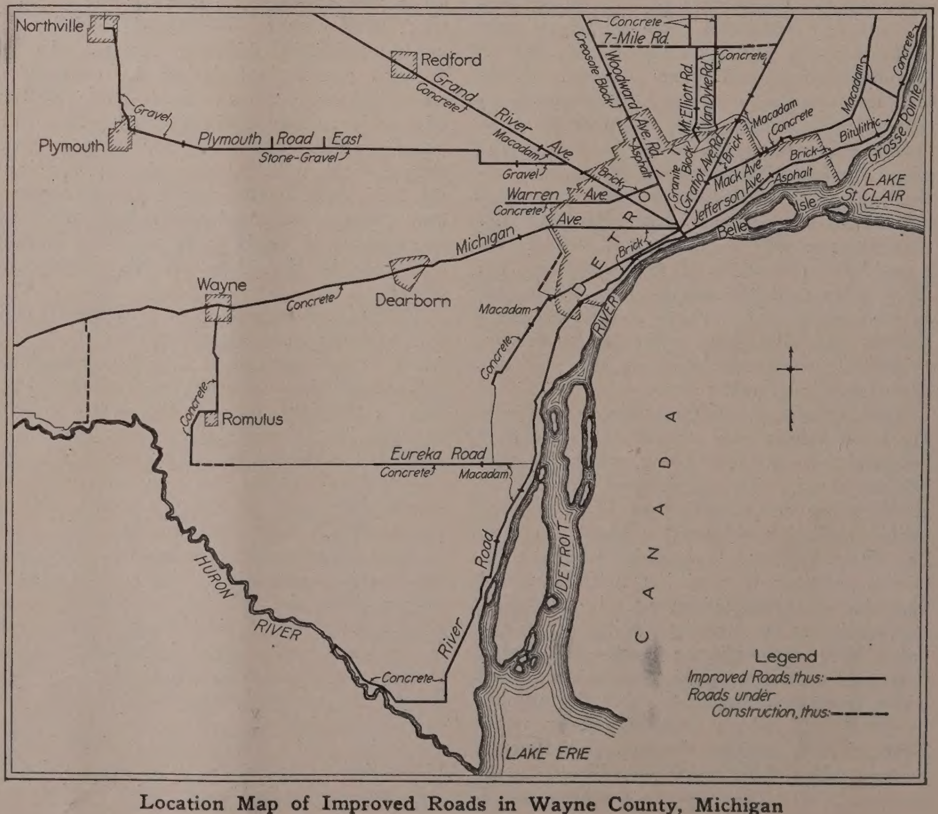
Building the Roads

Specifications for the roads now being constructed have remained practically unchanged for the last two years, but special attention is paid to get the surface flush with the Baker expansion joints, which are held in place rigidly until the concrete has set.

A special effort has been made to teach the men to trowel away from the joint rather than toward it, as the latter process invariably results in depressing the surface each side of the joint.

Many of the men, mostly Italians, have been on the work since it was started by the day-labor system four and five years ago and have become skilled. Nevertheless, they are continually watched by the inspectors and retained at certain positions to increase their skill. It is desired to get the traffic down to the stones in the concrete as soon as possible so that no tamping is done which might bring mortar to the surface. In two months' time traffic on a trunk road wears the surface to such an extent that the pebbles begin to show the mosaic effect, and thereafter they take practically all of the wear.

When a road is taken over as a county road it is given a name, usually the one by which it is known to the general public. A survey, plans and profile are then made and filed with the State Highway Department, together with a copy of the specifications and an application for State reward, after which the subgrade is prepared, shaped and rolled hard with a 10-ton roller. The concrete is laid right on the natural subsoil. Side rails of 2 x 7-in. lumber are protected on top by a 2-in. angle iron. When the concrete has become sufficiently firm to permit the removal



Location Map of Improved Roads in Wayne County, Michigan of the rail, the finishers pare off the outer edges which are formed next to the rails, to prevent a sharp dividing line between the concrete and the gravel shoulders.

Trunk roads are built 16 ft. wide, with gravel or limestone shoulders 4 ft. wide on each side. The lesser traveled roads have 12 or 15 ft. of concrete with a minimum width over all of 24 ft.

The concrete is deposited wet, so that no tamping is necessary after it is placed. When this is done no workman is permitted to disturb the surface by stepping or throwing anything on it, or in any other way. The strike-off men use a plank trimmed to the curvature of the road and iron bound on the lower edge. It rides smoothly on the iron edges of the form boards, or rails, at the side of the concrete, and is handled with sufficient care to eliminate the necessity for any considerable floating by the follow-up men. These floaters work on a bridge which rests on the form planks at the edge of the road, so that there is never any contact with the concrete. This rule to keep off the concrete is rigidly enforced. Smoothing is done with simple wooden floats of home manufacture.

Each day's work is finished up to an expansion joint and no more than twenty minutes are permitted to elapse between batches during the day. The work of the day is covered with canvas, and the next day, to keep the concrete from drying out too rapidly, the canvas is removed and the concrete covered to the depth of about 2 in. with available sand or loose soil. The concrete is sprinkled continuously for eight days. Roads are not opened for at least two weeks after the last concrete is put in place.

The gravel or stone shoulders are put on in layers 3 in. deep and rolled with a 10-ton roller. This work is not started until the adjacent concrete is at least three weeks old.

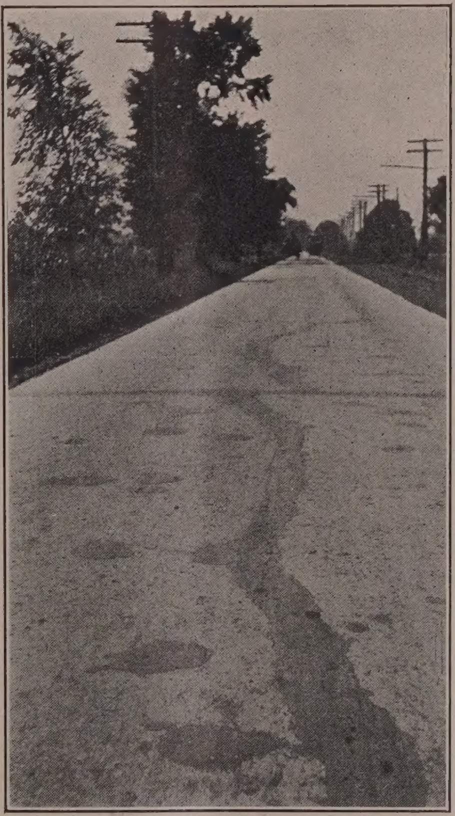
Machinery is used wherever the same or a better result can be secured. Traction engines trail from two to four 7-ton wagons. Graders are also drawn by steam tractors, which do the work of from six to eight horses more efficiently and more rapidly. Old roads are rooted up with a scarifier or gang plow. Water is pumped for miles by gasoline engines. Stone and sand on some of the roads are unloaded with a steam grab bucket.

As the mixer and gang work backward toward the base of supplies, hauling materials to be used to the road is done with considerable nicety, so that it is usually unnecessary to haul in extra sand or pebbles to make a properly proportioned batch.

The subgrade is thoroughly wet before any concrete is placed on it, in order that the water will not be absorbed from the concrete. The roads are built in 25-ft. sections, with a protecting plate 3/16 in. thick and 3 in. wide at each contraction joint. These metal plates are intended to protect the edges from spalling and chipping. They are shaped to conform to the crown of the finished road, which has a slope of ¼ in. to the foot. Two thicknesses of asphalted felt, of about ¼ in., are inserted between these metal plates, cutting the entire depth of the concrete. The plates are provided with shear members which tie them securely to the concrete.

One-Foot Tar Splotch over 1-Inch Hole

Work is now going on with three crews. A typical outfit is now building the Seven-Mile Road, which connects, as an outer belt, Gratiot, Van Dyke, Mount Elliot and Woodward Avenue roads. With a ⅓-yd. mixer thirty-six men, including those spreading earth on the finished surface, sprinkling and preparing the subgrade, lay from 500 to 600 ft. per day of 12-ft. road. Shortage of water—as many of the wells in the vicinity are dry—retards the work, but the men are then placed on trenching, as may be seen in one of the photographs. Concrete in the proportions of 1 part Universal Portland cement, 1½ parts sand and 3 parts gravel is deposited between steel channel-iron side forms held in place by iron pins. Water, to the extent of 15,000 gal. per day, is pumped through a 2-in. pipe with outlets every 400 ft.



Cracks Covered with Tar

EQUIPMENT

Approximately $100,000 is invested in equipment, all of which is housed in the winter in two immense galvanized-iron steel frame sheds at Wayne. In the last five years $30,000 has been charged off for depreciation. Some of the heavier pieces of machinery are: Ten Port Huron 10-ton traction engines, three ½-yd. and three ⅓-yd. Austin cube mixers—all with street booms; sixty 7-ton steel Port Huron trailers, 15 miles of 2-in. pipe, ten Fairbanks-Morse gas engine pumps, eight Road King graders, one Acme and three Longnecker scarifiers, ten Port Huron horse-drawn sprinklers and a series of Miracle molds for 8, 12 and 24-in. cement tile, and two Brownhoist locomotive cranes.

Ditch at Side of Concrete Road

MATERIALS

All sand and gravel have been shipped in from points 175 miles or more distant. Pits at Pleasant Lake, Ind., Grand Rapids and Chilson, Mich., have been drawn on. Both portions of the aggregate are washed and screened. The gravel ranges from ¼ to 1½ in. in size and the sand from ⅛ in. down to dust, but the larger grains predominate.

It is the practice to store material during the non-working season at convenient points along the roadside, rehandling it the coming summer being more economical than the cost of delays to the working crews during the short working season.

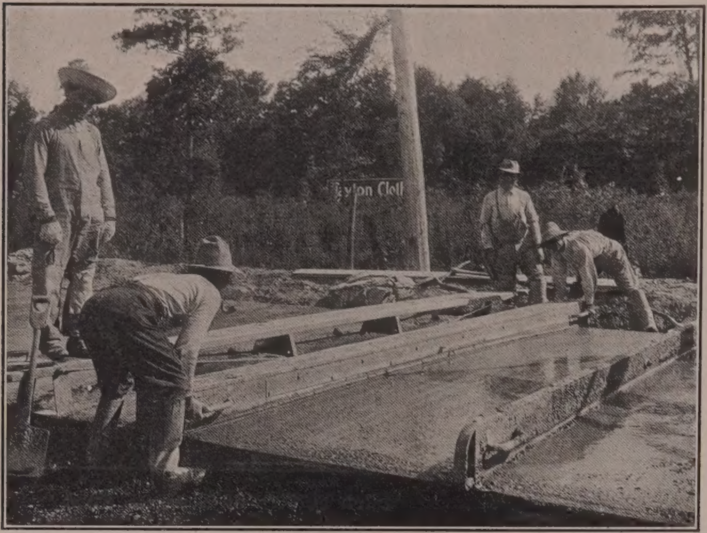
A combination of hauling engines and horse-drawn vehicles is used, as the former are impracticable over unimproved roads in wet weather. Under favorable conditions twenty-five cars have been unloaded with six men and the locomotive crane.

MAINTENANCE AND CONDITION

On the first road built near Wayne it is estimated less than ¼ in. has been worn off. On Gratiot Road, two miles from the city limits, is a 1¾-mile stretch of road that was built late in the season of 1910 and opened before it was perfectly set. It pitted badly under the heavy team traffic. Last year, as an experiment, it was covered with Dolarway; but too much material was applied and the surface became wavy and some peeling took place. This road has been retouched this season with a thin coating of Tarvia. As a result of their experience with this road and other short stretches, the commissioners advise that care be taken not to deposit too thick a layer. If it is not thick enough it is easy to increase it; but it has been found difficult to cut down a layer which is too thick.

All other roads have been gone over this season and all joints and pits are covered with tar from a wide-mouthed can, and then sand is sprinkled on. No costs separate from cutting of weeds, cleaning ditches, repairing bridges and culverts have been kept, with the exception of one road, where the cost of tarring amounts to less than $40 per mile.

As a result of this treatment of the joints the roads now have a smooth surface, but in appearance the joints show up vastly wider than they are, the tar men spattering the



Striking Board and Bridge for Floaters

Sprinkling and Covering Newly Laid Road

cracks and small holes liberally and the subsequent traffic ironing out the material to widths of 12 in. or more.

On an inspection trip early in September a representative of this journal examined some of the holes on Michigan Road by digging through the tar, revealing the fact that the tar men were covering pits as small as 1 in. in diameter, as shown in the photograph. The splotch around the pit was more than 12 in. in diameter, giving quite an exaggerated idea of the original hole.

Longitudinal cracks are attributed to settlement and transverse cracks to not cutting the expansion joint entirely through, a condition showing more often in the earlier work when the felt was not used but a strip of wood, which was subsequently pulled.

On Michigan Road along the river it was necessary to build a 24-ft. road over part of the fill, as the former road was 8 to 10 ft. narrower than the finished road. This road has a stretch of longitudinal cracks.

It is now the program to fill all expansion joints and incidental cracks the season following construction, as it is believed practically all openings will appear by that time.

On Van Dyke Road, where stretches have been constructed each year since 1910, it is practically impossible to tell anything about the relative age of the road either by walking or by riding over it.

At the beginning of Woodward Avenue Road, beyond the city limits, there is a stretch of 1 mile of concrete constructed in 1910. It has an inverted curb, which accounts for many of the longitudinal cracks. It is of two-course work, with the top of 1 to 3-in. crushed cobble or field stones. This material was used because it had been hauled to the job for a macadam road before concrete was decided upon. It has the typical mosaic appearance, which shows wear, but is in good condition.

So far the commissioners state not a single slab of concrete built by them has been torn up. On Grand River Road there is a 1½-mile length of concrete placed by contract under Redford Township officials which has gone to pieces. This has been replaced in large measure under the direction of the commissioners. Indicating the necessity of washed gravel and clean sand, it is stated that analyses of the concrete showed 14 per cent clay and a lean mixture.

ORGANIZATION

Three elected commissioners supervise the construction through an office employing a chief clerk and three assistants. Two engineers reporting to the board directly do the engineering work, with one assistant engineer and two helpers. Each crew is handled by a foreman who hires his own force, but the schedule of wages for certain positions are fixed by the board. The chief clerk employs the timekeeper, who is entirely independent of the foreman. All men are paid by check by a paymaster who travels from job to job. It is pay day somewhere every day. Last year supervision in the office cost $6,225. With this force were handled 1000 cars of material a month, as many as 1000 men on the payroll, and a disbursement of $600,000 for the 30 miles of road constructed.

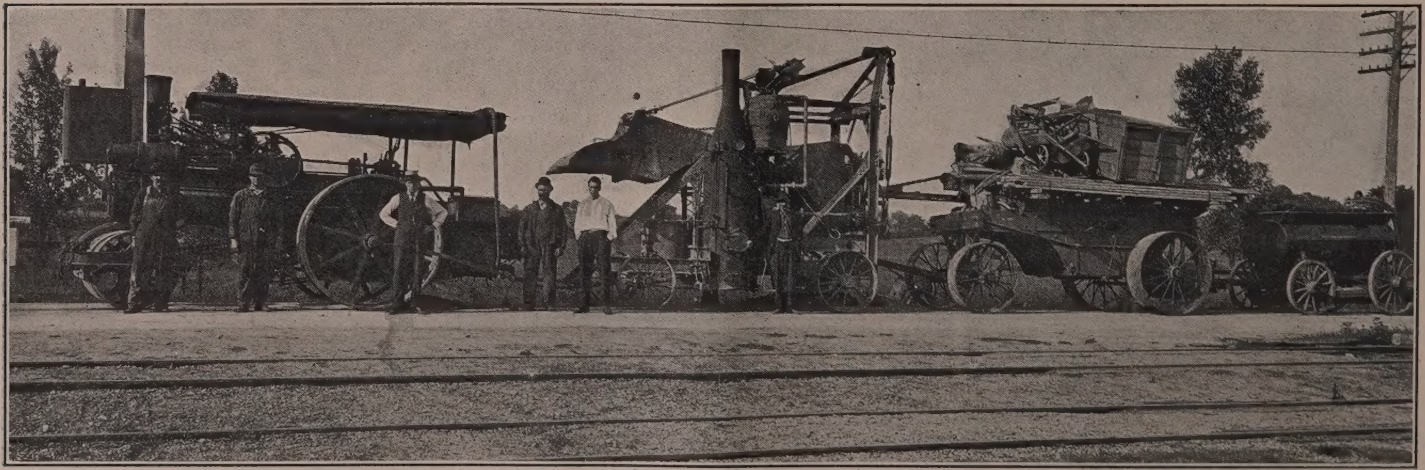
At the storage building is a storekeeper and assistant, who are engaged in making concrete tile when not attending to stock, which is only issued on requisition.

Reports are made daily by the timekeepers, who give information on the progress, unit costs, force employed, condition of supplies, a careful account of the cars and stock in them at the various sidings. All expenditures and orders are issued on suitable forms, copies of which are mailed to the office for checking of bills. Absolutely no oral orders are allowed.

The board of Wayne County road commissioners is made up of Messrs. William F. Butler, chairman; John S. Haggerty and Edward N. Hines. Messrs. G. A. Dingman, G. A. Burley and G. F. Key are the engineers.

Granite Production in United States

The production of granite in this country during 1912 was valued at $20,234,041, according to figures given out by the U. S. Geological Survey. Vermont, with an output worth $3,074,306, led; six other States produced more than $1,000,000 worth, and for seven others the output surpassed $500,000. Building stone represented $6,126,754 of the total; monumental stone, $4,643,919; riprap, $1,485,750; paving blocks, about $2,500,000, and curbing, flagging, crushed stone and the like, the remainder.



Traction Engine and Trailers for Hauling Concrete Road Equipment to Next Job

Flood Protection for Columbus, Ohio

Methods Proposed by Messrs. Alvord & Burdick for Carrying 150,000 Second-Feet Safely Past City

After the flood last March the city of Columbus, Ohio, employed the firm of John W. Alvord & Charles B. Burdick, hydraulic and sanitary engineers, of Chicago, to investigate the situation and recommend flood-protection measures. Their conclusions and recommendations, given below, are embodied in a report recently submitted.

CONCLUSIONS

The maximum flow of the flood of 1913 at Columbus was, in round numbers, 140,000 sec.-ft. Of this total approximately 80,000 sec.-ft. came down the Scioto and 60,000 sec.-ft. from the Olentangy River at the apex of the flood. The average flows for twenty-four hours at the flood apex were 68,000 and 51,000 sec.-ft. in the Scioto and Olentangy respectively, or a total of 119,000 sec.-ft.

Past records show that the average combined twenty-four-hour flood of the Scioto and Olentangy is about 33,800 sec.-ft. The flood of March, 1913, was therefore 3.52 times greater than the average flood.

Studies of other floods and flood data generally would indicate that, so far as records are available, the flood of March, 1913, was practically without precedent on this or other rivers of the eastern United States. Circumstances may occur to produce a greater flood hereafter, but it is not probable that such flood will greatly exceed the one just past.

The storm which produced the flood of March, 1913, especially in the extent of territory which it covered, was one of the greatest ever known in this country east of the Pacific Coast.

For the purpose of the protection of the city of Columbus against floods means should be considered by which a maximum flood flow of not less than 150,000 sec.-ft. could be safely carried by the city, with such clearance below bridges and excess height in embankments as would prevent debris from reducing the available cross-section or create accidents at the time of greatest emergency.

It is thought desirable, further, to consider the means by which floods of more than 200,000 sec.-ft. can be cared for in a similar manner, so that the authorities and the public may have their choice as to the amount and extent of flood protection which should be introduced at this time because the size of future floods cannot be accurately predicted.

It is believed that channels or flood-relief measures based on either of these two stated flow rates should be so proportioned and so safeguarded by height of levee, clearance below bridges, and factor of safety that the channels which convey them could, on emergency, carry one-half more than the computed flow before a great calamity or disaster similar to that of March, 1913, would occur.

Reservoirs on the upper watershed have been found practicable at reasonable cost, and for projects to carry 200,000 sec.-ft. a combination of reservoirs and new channel in the city is the cheapest, but for flows of 150,000 sec.-ft. projects for channels alone are slightly the cheapest.

Reservoirs aid not only Columbus but Delaware and the entire valley even as far as Chillicothe. Should any combination of interests be effected, and these benefits taken into consideration, projects in which reservoirs are combined with channels will have an advantage over all others.

Studies on the automatic control of flood flow by the detaining type of reservoirs have shown that with two reservoirs on the same stream, one above the other, the second adds but little to the total efficiency.

Further studies on this type of reservoir seem to show that with one reservoir on each river of the capacities here possible, a single reservoir on one of the rivers will be almost as effective in detaining the flood apex at Columbus as will the two. It has not been thought advisable, however, to reduce the estimated cost of reservoirs below two—one on each river—at this stage in the comparison of projects. If, however, a single reservoir is ultimately found to be practicable, it would reduce the cost of all the reservoir projects herein by $1,146,000—the cost of the Delaware reservoir project.

It has been determined that the cost of flood protection in the ten projects which have been investigated ranges from about $10,000,000 to about $23,000,000, in round numbers, and that no practicable measure of flood relief can be had at much less cost than the lowest figure mentioned, and that no greater sum could profitably be spent at this time than the higher sum mentioned.

The present value of the district flooded in March, 1913, all told, is estimated at the sum of about $50,000,000. It is further found that the damage done by the flood of March, 1913, as closely as it can be estimated, amounted to the sum of $5,600,000, and that this does not include the depreciation in real-estate values caused by the flood.

The annual flood damage for the past fifteen years in Columbus is not less than about $540,000 per annum, and, based on financial considerations alone, this would warrant the expenditure of from $10,000,000 to $11,000,000, to prevent the recurrence of flood disasters.

Undoubtedly the loss of life, distress, shock, and suffering caused by such a catastrophe would warrant a greater expenditure than this if it were found to be necessary.

It is believed that adequate flood relief, which will be safe, permanent, and satisfactory, can be had for from $10,000,000 to $11,000,000.

It is found that projects 1 to 6 inclusive are excluded both on the ground of their cost and for other lack of adaptability.

Projects 9 and 10, combining reservoirs with channels, are not favored unless State aid and the co-operation of other municipalities benefited be obtained. As between reservoir projects built by Columbus for its own protection and channel projects of equal cost, we favor channel projects as being a more simple and reassuring method to the public directly concerned.

Projects 7 and 8, providing for a flow of 150,000 sec.-ft. across the west side at May Street, in conjunction with or without the old channel, would appear to be the best and most economical projects, all things considered.

It is suggested that if the riparian owners will deed to the city their right to the abandoned lands in the present Scioto channel between Sandusky Street and Mound Street, so that it may be filled and either made into a park or subdivided and sold off as an asset, that project 7 be adopted. Project 7 provides for a new channel across the west side, known herein as the May Street cutoff.

If such riparian owners do not care to so concede their rights to the city, we would suggest that project 8 be adopted, providing for the retaining of the old channel around the bend, and rebuilding the present bridges, so that a flow of 50,000 sec.-ft. could be provided for through the present river around the bend; the remainder of the flow to be taken through a new channel to be cut across the west side in the vicinity of May Street.

Project 7, while apparently costing $1,176,000 more than project 8, has the following assets which do not appear in the estimate: 65 acres, more or less, of ground on the abandoned channel for park or other purposes. Decreased maintenance of two railroad and two highway bridges. Greater traffic facility from north to west side. In general, more compact, sightly, and improved conditions for the west side.

The total cost of project 7, amounting to $11,263,300, should be properly divided among the steam railroads, the city, the county, and perhaps other corporations or interests that will be benefited more than they will be damaged, and we would suggest that all parties at interest agree upon a Board of Arbitration which shall apportion these costs equitably among the parties at interest so that no time may be lost in proceeding with this great public work.

DESCRIPTION OF PROJECT 7

Project 7 provides for a total flow of 150,000 sec.-ft. with a factor of safety which would allow about one-half more flow before overtopping the levees. From the mouth of the Olentangy, where the rivers unite, the flow will be carried south through a new channel in what is called herein the May Street cutoff, joining the Scioto River again below Mound Street. The present bed of the Scioto River around the bend to Mound Street is to be abandoned, filled, and can be made into a park or boulevard, as may be desired.

The height to which it is proposed to allow the flood water to rise while carrying the above described amount of flow is much lower than that produced in the flood of March, 1913, above the city. This lower height is obtained largely by the fact that adequate and direct outlet is obtained through the west side, and in part by excavation and width of channel.

The new channel across the west side will about center on the line of May Street. It will be about 880 ft. wide at the top. The east line will be along McDowell Street, and the west line along Skidmore Street. The height of these streets will be raised to 46 ft. above city datum, or from 10 to 18 ft. above their present level. The width of the low water channel will be about 600 ft., and the water level held by the dam under the Mound Street bridge will be about 20 ft. above city datum. The bottom of the channel will be 12 ft. above city datum, giving a depth at low water of 8 ft.

LEVEES

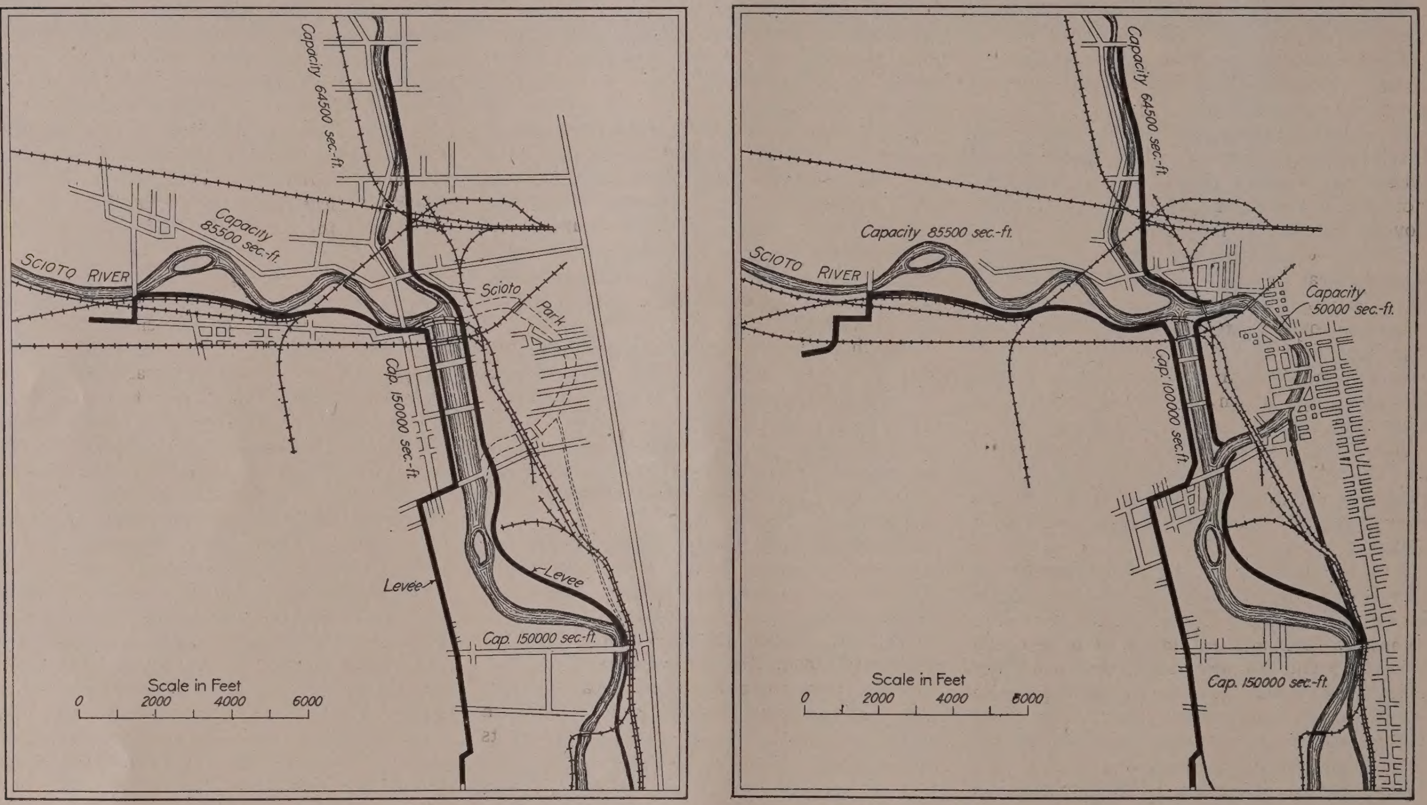
It is intended to protect the northerly line of the west side by a massive levee constructed along the Scioto River. This levee is to have a top width of 100 ft. and a height of 12 ft. above the high-water mark of the flood provided for. Another levee of importance will run north along the east side of the Olentangy bottoms to the high ground in the vicinity of Third Avenue, thus protecting the district north of the penitentiary from inundation. This latter levee will be 80 ft. in width, and of a sufficient height to be safe against all accidental ice gorges or other unusual conditions.

The old river bed, filled as it may be with the material taken from the new May Street channel, can be either made into an attractive park, or it may be so subdivided that a broad avenue shall pass through its center connecting with the city streets now existing, and all lands and lots thereby created may be either sold for the benefit of the improvement, or in part transferred to the riparian owners as compensation for their rights.

It is proposed to extend the dam of the light plant only.

It is proposed to build a levee connecting Mound Street with the Jackson Pike in the vicinity of Greenlawn Avenue. This levee will have a substantial breadth so that it may be converted into a drive, should the future improvements indicate that is desirable.

Considerable excavation will be necessary in the channel above Sawmill Island and below Mound Street.



Plans of Projects 7 and 8 Indicating the Main Features of the Flood-Protection Plans for the City of Columbus

The easterly levee below Mound Street will pass around the Franklin Iron Works, and thence southeasterly to the old canal bed and the high ground at a point north of the Greenlawn Avenue bridge, and here it will terminate. Below this point the flood plain of the river will be used as it now exists, practically between the old canal bed and the Jackson Pike.

The levees around the pumping station and the sewage disposal plant are to be raised and strengthened, but these works are not to be otherwise disturbed.

The old levees immediately along the river below Mound Street may be kept in place so as to protect from ordinary floods. The extraordinary floods which will be expected to overtop them will be confined by the larger levees and the broader flood plain herein provided for.

The cost of this work is estimated to be $11,263,300, if project 7 can be strictly followed. Of this sum it is believed that a substantial amount should be paid by the railroads, in part for improvements which they will receive and in part for proportionate costs which they should bear in any measure of flood relief.

Another portion of this amount should be borne by the county in caring for its bridges.

It is not known accurately what proportion will be necessarily raised by a bond issue by the city of Columbus, but it is believed that it will approximate 7½ to 8½ million dollars.

The creation of a new river channel through the heart of a populated district, involving, as it does, the condemnation of some seven hundred and thirty buildings, will of necessity occupy the attention of the legal department of the city for some time to come.

Advantages of Project

The following advantages are found for the recommended project:

It is believed to be planned with a factor of safety to make it adequate for the future flood protection of Columbus.

The more direct channel-way across May Street is an advantage in considering accidents due to ice gorges, wreckage, floating debris, etc., at times of large floods.

The project has all the elements of simplicity, directness, and visible assurance which can be comprehended by the population it is to serve.

It will add immensely to the value of property in the district lying east of the new channel by combining it with the heart of Columbus.

It will take less miles of levee to protect the west side than any other project of equal capacity.

It will reduce the number of bridges to be built and maintained by the city and county.

It will add greatly to the traffic facilities on the west side by connecting it more directly with both the north and south sides of the city.

It will recover more area of valuable land nearer the heart of the city than it will destroy.

The new channel for the river traverses the least valuable part of the west side.

This new channel will add greatly to the appearance of that part of the city by the introduction of the adjacent strips of park area, and by the permanent concrete bridges.

It will permit the present bed of the Scioto River, consisting of about 65 acres, to become a park or a boulevard, if desired.

It will eliminate four railroad bridges completely, substituting only two others.

It will amply protect the west side by the creation of a massive levee along its northerly side 100 ft. broad.

In the future, if desired, these levees can become desirable drives or parkways both to the north and the south side.

By the necessary acquisition of bottom lands to prevent encroachment, it will create an immense open or common ground for the entire city which, in a restricted manner, may ultimately be developed into a park system.

It will keep the river above Mound Street clean at low water, and create pools or ponds.

TABLE OF COSTS OF RECOMMENDED PROJECTS 7 AND 8

	Totals, Project 7	Totals, Project 8
Preliminary expense, 1 per cent..	$80,800	$71,800
Land	3,088,000	2,657,500
Direct damages	60,000	60,000
Temporary bridges and streets....	46,000	80,000
Changes in water pipes	24,400	24,400
Changes in sewers	186,400	86,400
Changes in lighting	5.900	5,900
Excavation	2,416,000	1,841,500
Bridges	1,289,200	1,493,200
Dams and weirs	482,000	482,000
Control gates	11,200	11,200
Raising streets and new streets ..	418,500	384,500
Repairing levees	48,100	48,100
Administration by commission, 2 per cent	161,500	143,600
Engineering and superintending, 6 per cent	484,500	430,400
Loss of interest during construction, 3 per cent	242,300	215,300
Contingencies and indirect damages, 8 per cent	646,000	574.000
	$9,690.800	$8,609,800
Changes in railroads	229,000	229,000
Railroad bridges	926,000	880.000
Changes in street railways	65,400	63.800
Changes in other utilities	90.000	86.200
Add 20 per cent, detailed as above	262,100	251,800
	$1,572,500	$1,510,800
Grand totals	$11,263,300	$10,120,600

Asphalt Paving Cements and Road Binders

Necessary Qualities and Laboratory Methods for Determining Them

By J. W. Howard, C. E., Consulting Engineer on Roads and Pavements, New York

Public welfare demands, and many honest city, county and state officials, engineers and chemists free from commercial influences, and independent producers and contractors, desire to know the characteristics and qualities which asphalt paving cements and road binders should possess to be good for use in making pavements and roads. Now that more than $150,000,000 are spent annually on roads and pavements in the United States—a very large part of it for asphalt and bituminous pavements and roads—we realize the importance of knowing what qualities these cementing materials should have and what laboratory tests they must meet to assure good results.

Brand Name and Geographical Source

An experience of more than twenty-five years in America and Europe, examining and constructing roads and pavements and testing their materials, has taught the writer that to secure the most durable, efficient and economic results, asphalt cements and binders (except where necessary patents are required) should not be specified by brand names; nor should covert descriptions in chemical and technical language be used in specifications to describe specific brands, as in some city and state specifications, to the exclusion of equally as good, and often better, asphalt cements which compete with one another as well as with the one or two brands thus required. Such specifications usually emanate from selfish commercial or political interests, and must be sustained by questionable methods of promotion and otherwise.

Thirty years ago, when there were very few asphalts available, brand names were excusable. But with the present large number of producers of excellent refined asphalts, asphalt cements and binders, made from crude materials from the United States and other countries, it is in the interest of honest, economical public administration that good, definite, open specifications with plain, practical laboratory tests be everywhere adopted and enforced.

The city, county, state and independent users are not concerned in the geographical source or crude materials from which asphalt products are manufactured. Specifications should have no requirements regarding the source of supply or the crude materials, nor the manner by which they are made into asphalt products. That is solely a matter for the manufacturers. All refined asphalts, asphalt cements and binders are the product of refining and are necessarily manufactured or artificial products. A specification which refers to the crude asphalt or describes the process of manufacture of refined asphalt, asphalt cement or binders, should be looked upon with suspicion or rejected. Such specifications sometimes force inferior materials or high prices on the contractors and taxpayers. Contracts should specify the qualities and tests needed for good asphalt cements or binders for use in pavement surface layers, just as they specify the qualities and tests needed for good Portland cements for use in foundations.

Irrelevant Clauses

Objectionable specifications which "let in" or "exclude" one or another asphalt, with few real quality tests, have lately been used for some New York State highways, roads for the New York City Board of Water Supply, New York Park Department roads, and for highways in Pennsylvania. This is done by inserting irrelevant or useless tests for gravity, fixed carbon, paraffine, sulphur, etc., with special requirements or limits which fit the peculiarities of certain limited asphalt products, to the exclusion of others equally as good or better. Standard, essential, and useful tests are partly included and partly omitted, according to whether or not the asphalt product, thus secretly described (except to an expert), meets good requirements or not. Such wrong, unwise, and unjust specifications are being steadily eliminated by good men and even others who wish to "avoid the appearance of evil."

Engineers and others who prepare specifications must be careful not to copy commercially inspired ones, nor blindly adopt tests emanating from persons in the employ of any one interest. Avoid specifications and opinions if found in some inspired or incompetent books or in similar articles in technical publications. Scrutinize carefully specifications of other cities and states which have often been either inherited or written to favor a few and not to be open to all good asphalt cements and binders.

A few months ago, for instance, an article appeared in an engineering publication which set forth a mass of indefinite, indeterminate and irrelevant chemical and physical manipulations—with few exceptions not tests of qualities of asphalt products for paving purposes. The refined asphalts, asphalt cements and binders were in some cases not referred to as such, but as "residual pitches" and others, which the article seemed to favor, as "native asphalts." The crude materials from which the partly described, refined products were made were stated to be from California, Texas, Mexico, Trinidad, Bermudez (Venezuela), etc. Then followed conclusions not warranted from the premises or from such chemical tests as saturated hydrocarbon, paraffine scale, sulphur, residual coke, etc., which are non-essential tests, whereas essential tests for cementing strength, waterproofness, stability under heat, effects of impurities, etc., were omitted. The conclusion left the impression on the reader that the article favored one or two brands or products from certain sources, and decried or depreciated other products at least equally good, made from California, Mexican and other crude materials. This also appears in some technical books, ostensibly of a general nature. When closely studied they seem to favor materials from certain sources of supply, and do not provide specifications open to all good and durable asphalts and bituminous products meeting all necessary requirements for the construction of good roads and pavements.

Qualities which Asphalt Paving Cements and Road Binders Must Possess

While the producers of asphalt and bituminous materials are entitled to a hearing, the final decision as to what specifications, qualities and tests must be used is properly a matter to be determined by those who use and eventually pay for the construction and maintenance of pavements and roads.

All reliable and experienced engineers and chemists who have given close attention to the art of pavement and road construction know that certain basic qualities are needed in all asphalt paving cements and bituminous road binders. These basic and essential qualities are here arranged in tabulated form so that their separate importance, correlation and mutual complement of each other are apparent:

1. Adhesiveness, or cementing strength
2. Waterproofness, or freedom from injury by water
3. Immutability, or freedom from deterioration on exposure to sun and air
4. Cohesiveness
5. Ductility
6. Flexibility, or pliability
7. Malleability, or ability to yield to shock without cracking
8. Consistency at mean weather (77 deg. Fahr.) temperature, proper for the kind of pavement or road
9. Minimum susceptibility to softening or stiffening during extreme weather temperatures
10. Purity, or high percentage of bitumen
11. Freedom from impurities of a vegetable or other deleterious character
12. Freedom from injury by heat necessary when melting for use.

Let us briefly consider what relation these twelve qualities bear to the finished pavement or road, and what laboratory tests conclusively determine these necessary qualities, in advance and during the construction of a pavement or road.

Adhesiveness

1. Adhesiveness, or cementing strength, is a self-evident quality needed to cement together the particles of mineral aggregate of a pavement. The laboratory test which determines the strength or adhesion of an asphalt cement or road binder is made by measuring the tension in pounds per square inch needed at 77 deg. Fahr. to break a standard briquette made of the asphalt cement and sand. The briquette is of the same shape and size as Portland cement briquettes and is tested in the same kind of a machine. The sand used is 20-30 standard Ottawa sand. The proportions used are 90 per cent. of sand and 10 per cent. (if practically pure bitumen) of the asphalt cement. If the latter is not pure, then its pure bitumen is extracted and used. The briquettes when made are compressed to ultimate possible density and cooled. The records of each briquette and the average of three should be recorded.

Effect of Water

2. Waterproofness, or effect of water, is a very important quality, because pavements and roads are constantly exposed to rain and other moisture from above, by capillary attraction from below, and by water which enters along and around rails and manholes, at curbs and other openings, and into slight cracks. If an asphalt cement is not waterproof, vegetable matter, soluble salts, earthy and other matter in it will decay, the cement will lose its binding strength and the pavement will disintegrate. All specifications should have, like those of Washington, D. C., and some other places, a requirement preventing the use of asphalt cements affected or injured by water. The laboratory test for waterproofness, or water-weakness, it might better be called, is made by coating a strip of glass with the proposed asphalt cement or binder and immersing half of the glass under pure water, the other half being left in the air to facilitate later comparisons. The water and the glass can be put in a sealed fruit jar. At the end of one week, and again after one month, an examination of the asphalt cement coating on the strip of glass

will show how seriously some asphalt cements are affected and decayed by contact with water. It must be remembered that all pavements and roads have tiny voids in them or are sometimes slightly porous, and that rain or other water may enter these voids; the asphalt cement is a thin film or layer on the sand or stone composing the pavement, similar to the layer or film on the sheet of glass which is being tested in water. The purer the asphalt cement, the higher the per cent. of bitumen in it, and generally the more waterproof it is. Those containing a large amount of organic or vegetable matter or other soluble impurities are generally injured by wet weather and especially by water standing upon such pavements, in gutters and depressions, or permeating it at any point.

Another method of testing waterproofness is to make standard cylinders composed of 90 per cent. of 20-30 Ottawa sand and 10 per cent. of the asphalt cement as received. The sand must be washed and dried and then heated and mixed with the asphalt cement. These cylinders are immersed in water and examined at intervals to show what effect water has on them, and whether or not they are softened or disintegrated. There is also an accelerated method by the use of steam vapor, not too hot, circulating against a film of thin asphalt cement or binder on a glass plate fixed in an inverted jar.

IMMUTABILITY AND COHESIVENESS

3. Immutability, or freedom from deterioration when exposed to sun and air, is very important because an asphalt cement or binder in a pavement or road must be unchangeable and not deteriorated and injured by the heat or chemical rays of the sun, or by the effects of air and other elements. It must retain its life and qualities. The test which determines this quality is the well-known standard test made by heating a given quantity in a specified sized vessel at 325 deg. Fahr. for five hours, limiting the permissible per cent of loss, and providing that the asphalt cement or binder shall not be hardened by this heating more than a prescribed limit—in extreme cases, 50 per cent. The determination is made by a penetrometer or by the consistometer.

4. Cohesiveness is needed to prevent an asphalt cement or binder from pulling apart or cracking within itself, although it may firmly adhere to the sand, stone or other aggregate of the pavement. This quality also helps prevent displacement or deformation of the pavement itself into waves, depressions, etc. The laboratory test for cohesive strength is made with the same mixtures of standard Ottawa sand and asphalt cement as described under quality No. 1 for adhesiveness, but the specimens are cylinders about 2 in. in diameter and 2 in. long (not briquettes), which are crushed in a testing machine at a temperature of 77 deg. Fahr. The load in pounds per square inch at which the cylinder crushes or is deformed is the measure of cohesive strength. This may also be referred to as the compression test. The records of each and the average of at least three such tests should be recorded.

DUCTILITY AND FLEXIBILITY

5. Ductility, or ability to yield without breaking, is a well-known requisite. Slight displacement of the particles of sand or stone of an asphalt pavement or road, due to the shocks of hoofs or wheels, makes it necessary that the asphalt cementing or binding material should yield and stretch a little and not break. It is also necessary that a pavement can contract from cold without cracking. Therefore some ductility is needed, but not too much, as that permits too much yielding and displacement of pavement or road materials, especially in warm weather. The well-known method of testing for ductility is by means of a small briquette having 1 sq. cm. cross section at its smallest part. This briquette is stretched at 77 deg. Fahr. until it breaks and the distance stretched before it breaks is recorded in centimeters.

6. Flexibility, or pliability without brittleness, is needed for practically the same reasons as given for ductility, and because slight settlements or deformations of a pavement or road foundation require that the pavement should be at least slightly flexible and yield without cracking. The laboratory test for this is to coat a strip of very thin glass, about 1 in. wide, with about ⅛ in. of asphalt cement. Make a scratch across the glass at its center on the side opposite the asphalt cement. Cool in water to 77 deg. Fahr. and with the fingers and test piece under water, break the glass toward the asphalt cement and continue bending the test piece, noting whether or not the asphalt cement or binder can be bent through 180 deg.

CONSISTENCY AND EFFECT OF TEMPERATURE

7. Malleability, or ability to yield to shock without cracking, is needed in an asphalt cement to enable it, under blows of hoofs and wheels, to conform to the slightly changing and irregular spaces on the surface and within the mineral aggreate of a pavement or road. The test for malleability in the laboratory is to try it with a small hammer, having the asphalt at different temperatures and the hammer wet.

8. Consistency at mean weather (77 deg. Fahr.) temperature, proper for the kind of pavement or road.—This means that the right degree of hardness or softness, called consistency or penetration of the asphalt cement or binding material, shall be used. Experience of many years shows that harder asphalt cement is needed for sheet-asphalt pavements of sand, powdered limestone and asphalt cement, than for pavements containing crushed stone. The degree of consistency also depends on the amount of traffic, materials used, climate, etc. The consistency is tested with a penetrometer having a standard No. 2 needle weighted with 100 grams. The needle is applied for 5 seconds and the depth of penetration into the asphalt cement is recorded in hundredths of a centimeter. For all penetration tests the writer prefers the uniform method of using the same weight (100 grams), the same time (5 seconds), and the same needle (No. 2), varying only the temperature. He prefers the temperatures 32, 77 and 100 deg. Fahr. When penetration tests are made at 32, 77 and 115 deg. Fahr., varying the weight and the time of penetration, complex results are secured and the changes in the asphalt cement are not solely due to temperature. The most scientific and accurate method for determining consistency is with the consistometer (Abraham), which measures the pressure in grams or kilograms needed to force a standard plunger into the asphalt product at a uniform rate of speed.

9. Minimum susceptibility to softening or stiffening during extreme weather temperatures.—All asphalts and bituminous paving and road cements and binders are softened by hot and stiffened by cold weather. Thus far it has been impossible to devise asphalt products which will not do this. All good ones, however, do not become too soft or fluid in hot weather, nor too stiff in cold weather. The laboratory test which establishes the permissible limits of susceptibility to stiffening and softening are made by use of a penetrometer or the consistometer at 32 and at 100 deg. Fahr., or at other degrees if called for. All should have some softness at 32 deg. and some stiffness at 100. The consistencies should accord with the special asphalt cement or binder needed for the location, materials and kind of pavement to be constructed. The consistency can also be tested by causing definite pieces and shapes of asphalt cement to flow on plates of glass or on metal sheets, and also by testing with a special disk which floats until the heated binder permits it to sink. The time for the float to sink is recorded.

IMPURITIES AND INJURY BY HEAT

10. Purity, or high percentage of bitumen, is of importance for several reasons. It excludes foreign matter, which is often injurious, and by its weight increases the expense of transportation and handling. It is useless matter which is not cementitious. Impurities reduce the quantity or area of pavement a ton of asphalt cement or binder will construct. Impurities cause delay from periodically cleaning sediment out of melting kettles and call for agitation by blowing, which sometimes injures the cement, or, if neglected, causes variations in the quantity of bitumen remaining in the cement, especially near the bottom of melting kettles, toward which the impurities settle. From an economic standpoint, asphalt cements and binders might be purchased on the basis of their percentage of purity or bitumen content, or there might be a reasonable penalty or deduction for the quantity of impurities or matter not bitumen present in them. The test for the percentage of purity is made by the universal method of extracting the bitumen with carbon bisulphide or with chloroform.

11. Freedom from impurities of a vegetable or other deleterious character.—This is a requirement which is the corollary or converse of purity or quality No. 10. Reasons have been there stated for some objections to impurities. The kind and nature of the impurities should be tested in the laboratory. The presence of vegetable or some other organic matter, or water-soluble salts and the like, often weaken the permanent cementing strength and durability of an asphalt cement or road binder.

12. Freedom from injury by the heat necessary to melt the asphalt cement or road binder for use.—Because all asphalt cements or road binders must be heated to be sufficiently fluid to mix thoroughly with and coat the mineral aggregate composing the pavement or road, it is necessary that they should not be injured by being thus heated and maintained in a fluid state for a reasonable length of time. The test for this quality is the same as for No. 3, immutability. The degree of heat used in construction is seldom, if ever, as severe as the test heat—325 deg. Fahr., during 5 hours. In connection with the testing of the stability when heated, the flash-point of the material is determined as a precaution either by the open crucible method or in the New York State closed tester, there being little difference in the results of the two methods. The flash-point is generally required to be above 350 deg. Fahr.

These twelve qualities are those which an asphalt cement or road binder should have in order to be acceptable for making good roads and pavements. The tests indicated are those which a properly educated and experienced engineer or chemist, equipped with a suitable laboratory, can make.

There is of course a great deal of chemical and physical research work which is necessary and useful to those who obtain crude materials and manufacture refined asphalts, asphalt cements, road binders, etc. But research tests should not appear in specifications for pavements and road construction. Some of the laboratory tests which do not apply directly to the quality of the finished asphalt products and are now best omitted from the specifications, are the following: Percentages of solubles in 62 B., 75 B., and 88 B. naphtha in sulphuric ether and in carbon tetrachloride; melting or flow point (which varies with the apparatus); viscosity (which varies with the instruments). The fixed-carbon test, designed for coal, has practically nothing to do with the finished quality of a refined asphalt, asphalt cement or road binder. It is a brand-identifying test. Free carbon, or amount of coke present, is interesting as reducing the amount of bitumen present but of itself does little or no harm and can be regarded as so much impurity or foreign matter.

Specific gravity is not a test of quality, except insofar as it indicates the amount of impurities (silica, limestone, etc.) present, these being heavier than pure asphaltum or bitumen. It is also used to help identify a special brand. A specific gravity clause is no longer necessary in specifications. The tests for purity and impurities (Nos. 10 and 11) are better, and they eliminate the specific gravity test in specifications. Specific gravity is still in some specifications, which thereby often exclude as good or better materials.

The determination of the percentage of paraffine scale, of sulphur and its compounds, of saturated hydrocarbon, etc., are interesting in research work in connection with the manufacture and production of asphalts and their compounds, but should not appear in specifications. The determination of the amount of hydrogen, carbon and other ultimate elements of asphalt is interesting as a scientific study, and bear somewhat upon the commercial and engineering problems connected with the sources of supply and manufacture, but have no place in contracts and specifications.

NUMERICAL REQUIREMENTS

In an article of this kind and brevity it is not possible to state the numerical requirements and limits of asphalt paving cements and binders for all the different kinds of pavements and roads into which they enter. Standard methods of making the tests to establish the requisite qualities enumerated in the table are found in various publications of the American Society for Municipal Improvements, the American Society for Testing Materials, the reports of the Association for Standardizing Paving Specifications, and in various other scientific publications.

A set of "Standard Tests for Asphalt Cements for Sheet Asphalt Pavement" with numerical requirements or standards, prepared by the writer, will be found in the "Proceedings" of the American Society for Municipal Improvements for 1911. That set of requirements and standards was the first published for sheet asphalt pavement composed of sand, powdered limestone and asphalt cement, and contained twenty-seven tests. A few of them are no longer needed for specifications, but were inserted to check or confirm some of the other tests. The requisite twelve qualities given in this article which good asphalt cements and road binders should possess are found in many products made from crude materials coming from California and other parts of the United States, from Mexico, Cuba, Trinidad, Venezuela and elsewhere, all of which asphalt cements and road binders are in successful use everywhere.

Experiments in Brick Road Construction

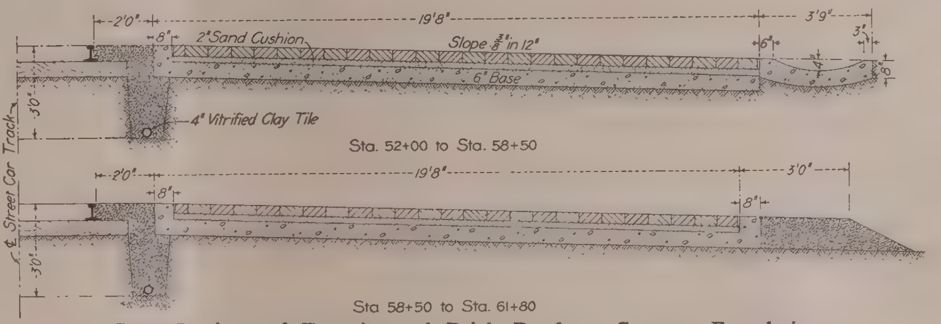
Test Data and Costs of Section Containing Fourteen Varieties of Paving Block

By James T. Voshell, U. S. Senior Highway Engineer, Office of Public Roads, Washington

During the fall of 1912 and spring of 1913 the U. S. Office of Public Roads, co-operating with the county commissioners of Montgomery County, Maryland, constructed a section of road 6180 ft. in length, beginning at Bradley Lane and extending north on the Kensington Road (Connecticut Avenue extended) to Chevy Chase Lake. The section was built to determine the relative values of several more or less standard pavements and of various roadbuilding materials.

Experiments 1 to 5 inclusive, comprising sections of bituminous concrete, of cement concrete with various coarse aggregates and flush-coated with various bitumens, have been described in a previous issue of the Engineering Record and in the 1913 progress report issued by the Office of Public Roads.

Experiment 6 is a pavement constructed of vitrified brick. It is 980 feet in length and has the cross-sections shown in the drawings on this page.



Cross-Sections of Experimental Brick Road on Concrete Foundation

The soil over which the pavement was built is a decomposed mica schist which absorbs water very readily. A double-track street railway parallels the pavement; the area between the tracks is unpaved. A French drain, therefore, was constructed along the edge of the pavement throughout its entire length, to prevent water from reaching and softening the subgrade.

TABLE 1—ANALYSIS OF CUSHION SAND

	Per cent
Retained on ¼-in. sieve	0.0
Between ⅛-in. mesh and No. 10 sieve	7.1
Between No. 10 and No. 20 sieve	13.7
Between No. 20 and No. 30 sieve	18.9
Between No. 30 and No. 40 sieve	20.5
Between No. 40 and No. 50 sieve	16.8
Between No. 50 and No. 80 sieve	13.7
Between No. 80 and No. 100 sieve	1.4
Passing No. 100 sieve	1.1

Curbs along a brick road, as a rule, cost from 30 to 40 cents per linear foot, or from $3,000 to $4,000 per mile. As this is from 20 to 30 per cent of the total cost of the road, the need of a cheaper curb was felt to be very desirable, and the plan as shown in the section was adopted. No difficulty in the actual work of constructing it was experienced. Forms were set on the outer edge of the curb line with the top edge 6 in. above the proposed top surface of the base. The base concrete was then laid and immediately forms were set for the inside face of the curb and the curb concrete tamped into place.

The concrete for the curb was mixed by hand and was apportioned: 1 part cement, 1¾ parts sand, and 3 parts gravel. Care was taken to have it deposited in place before the concrete of the base had taken initial set. The cost of this curb, including the extra width of base, was 16.22 cents per linear foot. This form of curb, being put in as the base is laid, leaves the subgrade free of any obstruction to prevent teams from turning off it when hauling in materials for the base.

CONCRETE BASE

The base, 6 in. in thickness, is of concrete of the following proportions by volume: 1 part cement, 3 parts sand, and 6 parts gravel from ¼ to 1½ in. in size. The mixing was done by a self-propelled street paving mixer, at the rate of about 20 cu. yd. per hour. The concrete was dropped practically in place with a mechanical device attached to the mixer. A smooth, true surface, free from open and porous areas, was obtained by means of a straight-edge and a No. 2 shovel.

For the cushion sand was spread over the base to an approximate depth of 2 in. and struck off to a true depth of 2 in. by the use of a screedboard, the ends of which rode on the concrete curb. It was then rolled with a lawn roller weighing about 300 lb. Sand was then spread over the rolled surface about ¼ in. in depth and again screeded and thoroughly rolled. When the rolling was complet-

TABLE 2—RATTLER SAND-BLAST AND ABSORPTION TESTS

Brand	*Rattler loss, per cent	*Sand-blast loss, grams	Per cent water of absorption, 5 brick
Grafton shale (a)	38.89	84.5	4.04
Grafton fireclay (b)	37.68	50.5	2.38
Reynoldsville fireclay, Dunn wire cut (c)	31.19	28.5	3.68
McAvoy shale (d)	27.92	35.1	2.29
Metropolitan shale (e)	25.57	27.1	0.88
American fireclay (.)	24.31	44.0	3.73
Marion shale (g)	22.68	35.8	3.74
Townsend shale (h)	22.59	32.5	2.86
Peebles shale (i)	22.04	20.6	1.10
Olean shale, Dunn wire cut (j)	21.12	27.0	1.39
Nelsonville fireclay (k)	19.11	37.1	1.56
Barr shale (l)	18.80	41.5	1.81
Bessemer shale (m)	17.67	32.1	1.65
Tuna Valley shale, Dunn wire cut (n)	16.36	23.3	1.31

*Average of three tests.

(a) Comparatively soft-burned brick made from coarsely ground clay. The wear in rattler was excessive though uniform.

(b) Comparatively soft-burned brick made from coarsely ground fireclay. Wear in rattler excessive though uniform.

(c) The losses in the rattler were due mainly to open laminations, the brick being hard-burned.

(d) Medium hard-burned brick which wear evenly though excessively in the rattler test.

(e) The brick was well vitrified, the losses in rattler being mainly due to chipping.

(f) Fairly soft-burned brick made from medium finely ground clay. Worn down evenly by rattler.

(g) Medium-hard-burned brick made from finely ground clay and having a fairly good structure.

(h) Medium-hard brick made from coarsely ground clay and wearing down uniformly in rattler.

(i) The brick was very hard-burned, the losses in rattler being due to chipping.

(j) Hard-burned brick having a good structure.

(k) Made from coarsely ground fireclay, the brick having an excellent structure, free from laminations. Not burned very hard.

(l) Molded from coarsely ground clay. the brick having a good structure.

(m) Molded from coarsely ground shale, the brick having a fairly good structure and is hard-burned.

(n) Medium-hard-burned brick having a very good structure.

ed the sand cushion was so firm that when walked over no footprints were visible. Table 1 gives a granulometric analysis of the sand used.

Fourteen varieties of paving block were laid, all in the same manner, in sections 60 to 110 ft. in length. The report of tests made by the Pittsburgh branch of the U. S. Bureau of Standards is given in Table 2.

The sand-blast test was conducted with standard Ottawa sand, 20 to 30 mesh, screened after every test. The air pressure maintained was 15 lb. per square inch, and the sand was blown through an orifice ½ in. in diameter. The amount of sand used was 25 lb. per test, and the duration of the test was three minutes. The specimens were at a distance of 12 in. from the nozzle, and in each case a 2-in. opening was exposed. The specimens were rotated at a speed of 80 r.p.m.

TABLE 3—SAND ANALYSIS FOR GROUT

	Per cent
Retained on No. 10 sieve	0.4
Between No. 10 and No. 20 sieve	1.5
Between No. 20 and No. 30 sieve	2.8
Between No. 30 and No. 40 sieve	6.0
Between No. 40 and No. 50 sieve	30.6
Between No. 50 and No. 80 sieve	41.1
Between No. 80 and No. 100 sieve	4.1
Between No. 100 and No. 200 sieve	11.2
Passing No. 200 sieve	2.3

LAYING AND GROUTING BRICK

The brick were laid in straight courses at a right angle to the curb, as shown in illustration. No driving was permitted to straighten courses. After the brick were laid and all spalls and imperfect brick were removed they were rolled with a 5-ton tandem roller until they were firmly bedded on the sand cushion. The joints were filled with a cement grout composed of 1 part Portland cement and 1 part sand. Table 3 contains the granulometric analysis of the sand used.

TABLE 4—QUANTITIES OF MATERIALS AND COST DATA

Description	
Length of section, ft.	986
Area of section, sq. yd.	2,055
Quantities of Materials—Base	
Gravel, cu. yd. per sq. yd.	0.150
Sand, cu. yd. per sq. yd.	0.065
Cement, bbl. per sq. yd.	0.145
Pavement	
Sand cushion, cu. yd. per sq. yd.	0.061
Brick, number per sq. yd.	40
Sand in grout, cu. yd. per sq. yd.	0.005
Cement in grout, bbls. per sq. yd.	0.031

The sand was brought on the work in cement bags, and one bag of cement and one bag of sand were mixed dry to uniform color. Water was then added in sufficient quantity to give the resultant grout a consistence of thin cream. The grout was constantly stirred with mortar hoes until it was taken from the box with a scoop shovel and spread over the pavement, which had previously been well sprinkled. Men with rattan brooms swept the grout into the joints. This operation of grouting is shown in one of the photographs. After the thin grout had settled well in the joints, and before any of it had dried, grout of the consistency of thick cream was squeegeed over the pavement, leaving all the joints completely filled. Sand was then immediately spread over the pavement to a depth of ½ in. and kept wet for seven days.

TABLE 5—COST DATA FOR MATERIALS, CENTS PER SQUARE YARDS

Base	
Gravel	27.30
Sand	9.30
Cement	23.40
Mixing and placing	17.45
Pavement	
Sand in sand cushion	10.10
Preparing sand cushion	3.66
Brick	80.00
Unloading and piling brick from car	15.23
Hauling and piling brick by roadside	11.18
Laying brick	5.20
Rolling brick	1.76
Sand in grout	0.80
Cement in grout	5.08
Grouting	2.96
Protection	1.57
General	
Preparing subgrade	21.44
Superintendence	10.43
General expense	4.54
Miscellaneous	6.81
Total Cost	
Cost per square yard, in cents	258.21
Total section	$5,306.22
Concrete shoulder 6 x 8 in., 1350 lin. ft., at 10.12 cents per lin. ft.	136.59
Expansion joint, 1900 lin. ft., at 3.84 cents per lin. ft.	73.05
Concrete gutter, 650 lin. ft., at 54.52 cents per lin. ft.	354.38
French drain, 980 lin. ft., at 23.65 cents per lin. ft.	231.77
Total	$6,102.01

Laying Brick Paving Blocks on Sand Cushion

Grouting Joints of Experimental Brick Pavement

The thickness of a sufficient number of brick of each variety to lay two courses across the pavement was carefully measured. These brick were then laid, as the other brick, their location being carefully referenced so that at any future time they may be taken from the pavement, measured, and the amount of wear determined.

EXPANSION JOINTS

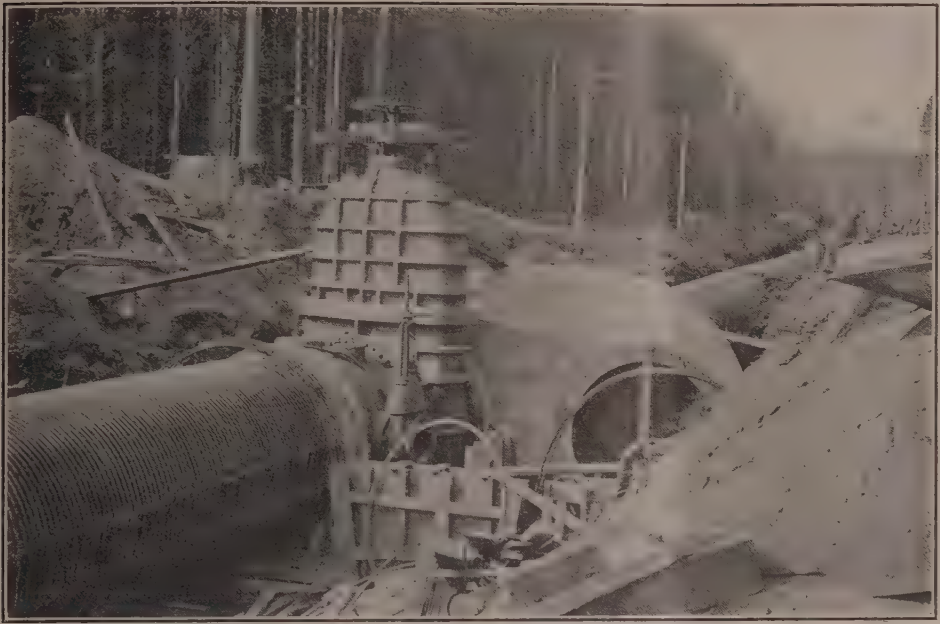
No transverse expansion joints were constructed, and the ends of the pavement are practically fixed. A longitudinal expansion joint was constructed along each curb line. From Station 52 to Station 54 it is 1 in. wide, and was filled with a mixture of equal parts by volume of coal tar and Portland cement. The coal tar had a float test at 50 deg. C. of 14 minutes, 57 seconds, and, as the pavement was on a 5 per cent grade, it was thought advisable to add something to the tar to prevent it from running out of the joint. Last summer the temperature of the pavement 1 in. below the surface was on one occasion 115 deg. Fahr., and there was practically no movement of the tar. The tar and cement were readily mixed when the tar was at a temperature of 250 deg. Fahr.

TABLE 6—UNIT COSTS

Labor	Per day of 8 hrs.
Superintendent	$10.00
Foreman	4.50
Rollerman	3.50
Engineer for mixer	4.00
Carpenter	3.50
Laborer	1.60
Team	5.00
Materials, F.O.B. Nearest Siding	
Sand	$0.70 per ton
Gravel	0.85 per bbl.
Cement	1.51 per bbl.
Brick	20.00 per M.
Contract Price for Unloading and Hauling Materials from Siding to Work (Average Haul, 3100 Ft.)	
Sand and gravel	40 cents per ton
Cement	10 cents per bbl.
Machinery	
Concrete mixer	$10.00 per day
Roller	5.00 per day

From Station 54 to Station 56 the expansion joint is ½ in. wide and filled with asphaltic felt. From Station 56 to Station 61 the expansion joint is 1 in. wide and was filled with an oil asphalt having a penetration at 25 deg. C. of 3 mm. and a melting point of 94 deg. C.

The grade of the pavement from Station 52 to Station 59 is minus 5.1 per cent; the street follows a vertical curve from Station 59 to Station 61 and a plus 1 per cent grade from Station 60 to Station 61 + 80. Detailed statements of the quantities of material, cost data and unit costs of labor and material are contained in Tables 4, 5 and 6.



Upper Y, where 96-Inch Pipe Branches into Two 72-Inch Pipes

Puntledge Hydroelectric Power Plant—Part II

An Ultimate Development of 19,000 Horsepower which Will Supersede Separate Steam Plants Used for the Operation of Coal Mines at Vancouver Island

Manholes are fitted to the wood-stave pipes at intervals, and particularly at summits, where they are provided with automatic air valves for the outlet of air during service as well as for the inlet of same when the pipes are to be emptied. The manholes consist of cast-iron saddles with lugs designed to receive the band heads, but the extreme side bands pass over the saddles, thus acting to clamp them on the pipe, no other means being used to secure the castings to the pipe. The manholes are closed with cast-steel covers bolted on the facings of the saddles. The stave pipes are laid in a shallow trench for practically the whole length, although in a depression for a distance of 820 ft. it was deemed more advantageous to hold the grade line elevated and to place the pipe on concrete piers. This section occurs on pipe 6 ft. in diameter, and the general design of the reinforced-concrete piers, which are placed 16 ft. between centers, is shown in one of the illustrations.

Y Junctions

Several designs were considered for the structures forming the junctions between the pipes of the different sizes. The first design was for structures built of steel plates riveted in alternative forms of wyes and cylindrical headers; but after considering the size of the structures, range and nature of the stresses introduced by attaching to them stop valves in the penstocks, the designs of riveted plates were set aside as unreliable, although the element of cost as between that type of structure and the design finally adopted was another factor in favor of the latter. The next design considered was for structures of cast steel, with the idea that steel castings could be made more rigid than the riveted steel structures and could easily be provided with suitable means for anchorage; but the cost of such structures, including the necessary foundations for support and anchorage, was also found to be excessive. The design adopted was one in which foundations and anchorage were most conveniently combined, and the design to which the structures have been built is reinforced concrete, a type of construction believed to be unusual for such high-pressure work. The junction between the 8-ft. pipe and 6-ft. pipes was designed for a maximum internal pressure of 115 lb. per square inch, and that between the 6-ft. and 50-in. pipes for a corresponding pressure of 160 lb. per square inch. The 8-ft. pipe connects directly with the first-mentioned structure, and the joint is made in a cast-iron ring set in the concrete forming a bell end for the wood pipe. Watertightness at the joint is obtained by the same means as described for the joint made where the same pipe leaves the forebay structure.

All other pipe connections with these concrete structures are made by means of flanged cast-iron sleeves set in the concrete to which gate valves are attached. The purpose of these gate valves is to enable the isolation of any one of the connecting pipes and the operation of the plant with one or the other of the 6-ft. penstocks and any one or all of the four 50-in. penstocks, which explains the reason for making the lower-junction structure a chamber common to the two inlet pipes, the four outlet pipes thus providing a by-pass connecting all sections of the penstock system. But, as will be readily understood, the introduction of stop valves in the penstock complicated the problem presented for solution in the design of these junctions, as forces of magnitude are thus developed which are not encountered in open-way penstocks, and it was the adaptability of reinforced concrete to designs meeting all conditions that prompted its adoption for such unusual duty.

The branches from these junction structures leave at an angle to the axis of the pipe line and the alignment of the stave pipe parallel to such axis is restored at a short distance below each respective structure by means of cast-iron pipe bends laid next and bolted to the valves and which are fitted with manholes, air valves and relief valves, the latter consisting of a flanged gate valve bolted to a facing on the side of the cast-iron bend with a bursting-plate cover bolted to the outlet.

Bursting Plates

The bursting plates consist of cast-iron flanges, or rings, within which is a cast-iron plate turned to such size as to leave an annular space of about ⅛ in. The inner edge of the flange or ring and the outer edge of the plate are made with a groove which is narrower in the edge of the plate than that in the edge of the ring. The annular space, which, together with the grooves, forms a cross of irregular shape in section, is filled with lead calked watertight, the idea of the design being to shear the tongue of lead formed by the groove in the edge of the plate and thus to release the latter in the event of unexpected excessive load. To accomplish this without undue friction the edge of the plate is turned with a taper, as shown in the drawing. The thickness of the inner tongue of lead is 3/16 in. in both sizes of plates, this having been determined after tests were made to ascertain the average shearing strength of the tongue under such conditions. Automatic air valves are fitted at these structures both for escape and inlet, the latter being essential to prevent a vacuum forming in and possible collapse of the pipe in the event that it should be emptied rapidly.

Waterproofing

Watertightness of the concrete structures was obtained by building the walls proper to within a thickness of 2 to 3 in. of the inner surface of rich Portland cement concrete, composed of fine aggregates of measured density, weight tests having been made to determine the proper proportions of the available aggregates for maximum density; and great care was exercised throughout to insure uniformity of mixture. The proportions in this concrete averaged 1 cement, 1 sand and 2 gravel, the latter varying from pea size to 1

Power House with Annex Containing Transformers and Switches in. The inner thickness of 2 to 3 in. was made up of Portland cement mortar of the composition of 1 part cement to 1½ parts of sand, the inner surface of this mortar coating being covered with several coats of asphalt applied hot. In the chamber of the structure for the junction of the two 6-ft. penstocks with the four 50-in. penstocks, only one-half of which is being utilized for the partial plant now built, the side which is not connected up is separated from the other by a removable wooden bulkhead, provision for which was made in the structure in the way of rabbets armored with steel shapes set in the concrete. This feature of the design was provided on both sides in order that similar isolation of one side or the other can be readily effected at any time in the future should such be necessary. As indicated by the design, the anchorage of the concrete structures is accomplished by means of reinforced walls, approximately 7 ft. deep, buttressed to the wye structure and to the apron which forms the foundations for the valves and heavy cast-iron connections, the design providing amply against the overturning moment, as well as against sliding. The apron referred to constitutes also the floor of a drainage basin for the relief valves, the outlet of which is an open ditch to lower ground, with natural drainage to the river.

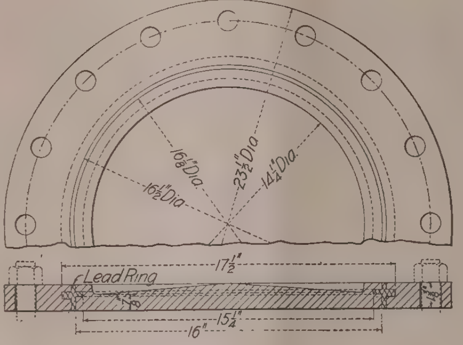
Lower End of Penstocks

Where the minimum spacing of bands is reached the type of construction is changed to steel pipes connected to the stave pipes by means of riveted steel tapered sections joined with the wood-stave pipes in a bell end provided in the steel section for the wood staves, of such shape as to allow calking at the outer end of the steel section, as well as against the inner ends of the staves. This steel section has angle-bar anchoring rings riveted on and is set in a concrete anchoring block forming the base of a chamber giving access to a manhole fitted on this section. The steel pipe, which is of the lock-bar type, is riveted to the special steel section just described. Each of these steel-pipe penstocks is 660 ft. long, their thickness varying from ⅜ in. at the upper end to 7/16 in. at the power house. The steel pipes are laid in trenches, much of which is in solid rock, and at about the middle of their length there are expansion joints, consisting of steel castings and of the usual packed slip-joint design. These joints are laid each in a concrete chamber and the steel pipe is laid in tarred felt through the walls of this chamber, leaving it free to slip. The lower ends of the steel penstocks are anchored near and at the power-house foundation and terminate within the building, with a cast-iron closing piece connecting them to hydraulic shutoff valves installed at the respective turbines.

Power House

The power house is built of reinforced concrete on a rocky site at the river's edge. Approximately one-half of the principal building contemplated has been erected for the accommodation of the present units, but the annex section of the building, which contains the switching and other electrical apparatus and the wire outlets, is built complete. Provision has been made in the design for extension of the main body of the building to house the remaining units without disturbance to the operation of the present plant.

The annex section, which is three stories high and has a 18½ x 65½-ft. floor area, has the upper floors of concrete supported by I-beams. The roof of the entire building is built of concrete laid on Hy-Rib reinforcement plastered underneath. The roof framing of the annex section consists of 9-in. 21-lb. I-beam rafters; that of the main section consists of steel trusses placed 20 ft. center to center, supporting 9-in. 21-lb. I-beam purlins. The sides of the building are, in large proportion, of glass. The main building is designed with crane girders, on which a traveling crane having a lifting capacity of 40 tons has been installed. These girders are of reinforced concrete, with the runway rails embedded therein. All of the concrete in the exterior of the building was made of waterproof composition obtained by the use of hydrated lime in the mixture in the proportion of 10 per cent of the cement used, and the roofs are covered with roofing felt. The roof drainage is run through the interior of the building to a central drain to guard against frost in the conductors.



Detail of Bursting Plate

Scheme of Regulation.

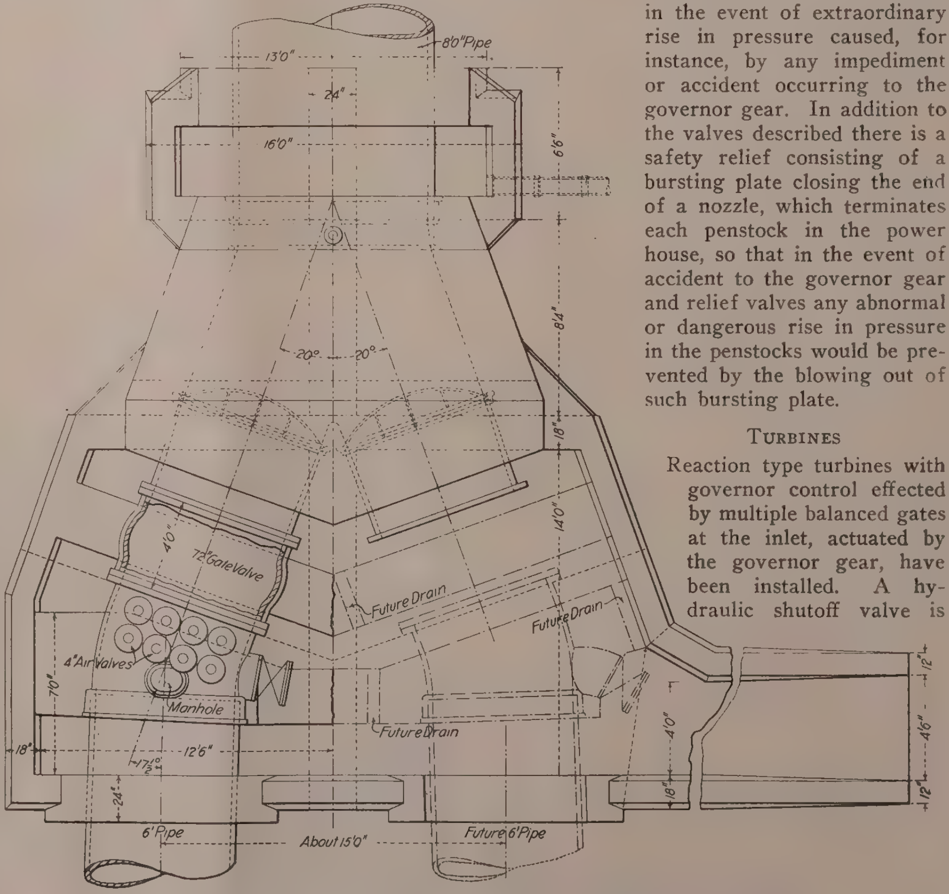
The static head is 350 ft.; the length of the penstock system being 13,700 ft., the ratio of the pipe is about 1:40. The part played by a high ratio of head to length of penstock, as an unfavorable factor in the solution of the problem of power regulation under variant-power-load conditions, was fully realized and much study was given to the general scheme with a view to obtaining the most favorable combination, but the ratio obtained was the best available owing to the naturally unfavorable topographical conditions and to the fact that the forebay is located at the nearest suitable point in relation to the power house, the general slope increasing from this point gradually to the power-house site. The problem presented in laying out the penstock system from the site selected for the forebay to the power house was therefore confined to locating the best available grade line, considering the details of construction and existing property lines. In a penstock system of such a high ratio of length to head it is difficult to obtain power regulation by means designed to conserve the water supply, but inasmuch as there was no scantiness of supply and economy of water was not a factor in the design of this plant the problem of regulation as presented was comparatively simple.

The arrangement adopted insures against sudden or high rises in pressure in the penstock system as an effect of throttling of the turbine gates by the governor gear of each turbine operating a relief valve on its penstock, which opens and closes synchronously with the corresponding action of the turbine gates, thus permitting water to waste in approximate proportion to the load taken off, and maintaining so nearly a uniform rate of flow in the penstock as to prevent the pressure rises due to governor throttling to exceed a nominal percentage of the pressure due to the active head. This valve is geared so as to be adjustable to close in any desired length of time, so that waste of water need be no more than sufficient to diminish the penstock flow at a safe rate.

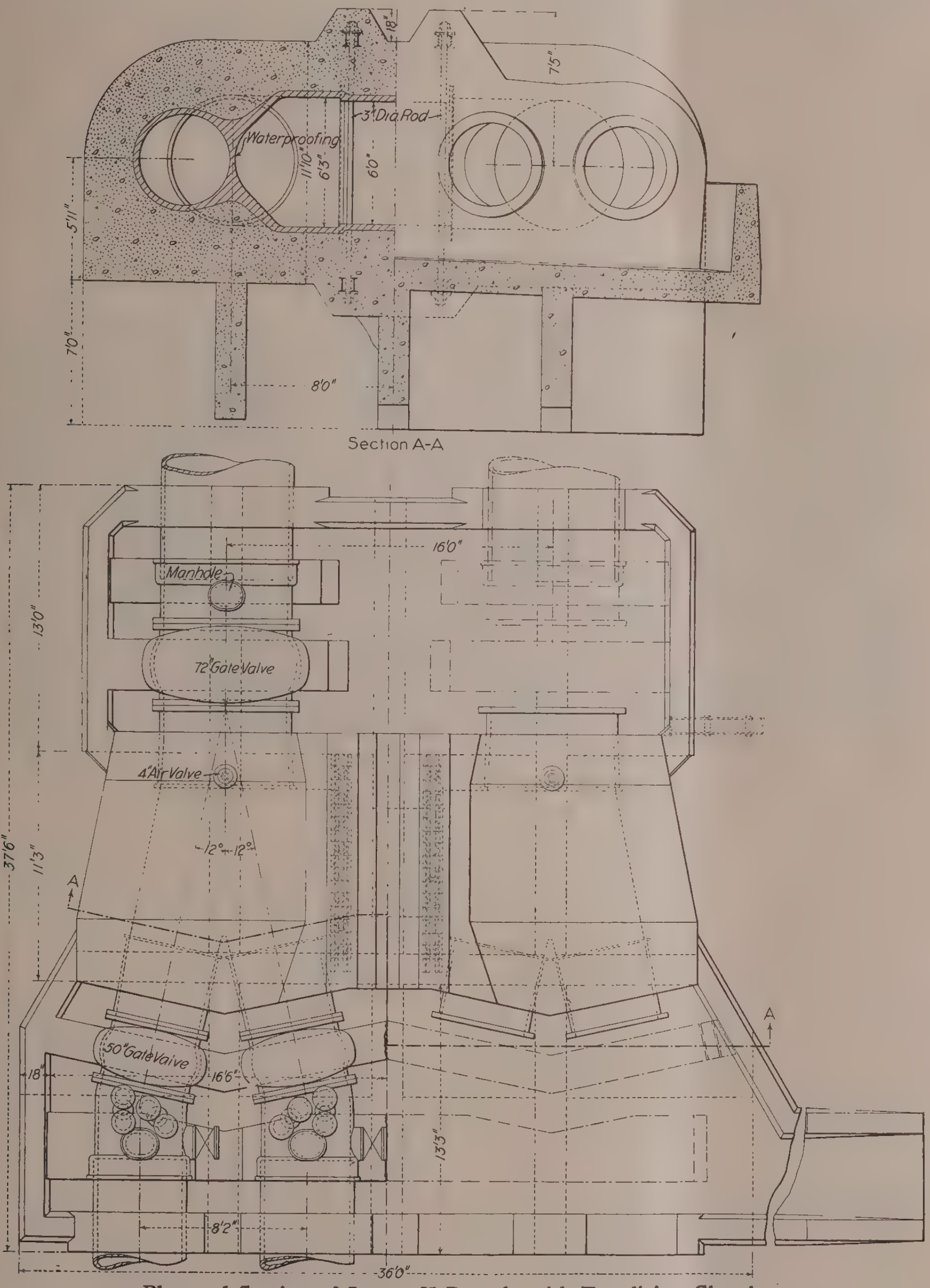
The general arrangement as designed includes, in addition to the governor actuated relief valve, a direct-pressure independent relief valve which would open in the event of extraordinary rise in pressure caused, for instance, by any impediment or accident occurring to the governor gear. In addition to the valves described there is a safety relief consisting of a bursting plate closing the end of a nozzle, which terminates each penstock in the power house, so that in the event of accident to the governor gear and relief valves any abnormal or dangerous rise in pressure in the penstocks would be prevented by the blowing out of such bursting plate.

Turbines

Reaction type turbines with governor control effected by multiple balanced gates at the inlet, actuated by the governor gear, have been installed. A hydraulic shutoff valve is



Detail Plan, Showing General Arrangement of Upper Y Branch placed in each penstock in conjunction with the turbine. These machines are direct-connected to their respective generators. Specified rating of each turbine is 4700 hp under the conditions to be obtained when the penstock system is completed, and supplies four units at full power. For present purposes only two of these units are installed, and inasmuch as the upper portion of the penstock system is already constructed of the requisite capacity for four units the available power of the two turbines now installed exceeds their rating to the extent of 28 per cent in the case of one turbine operating alone and 7½ per cent when both are running at full gate. In general arrangement within the power house the machines are placed with the shaft axis parallel with the longitudinal axis of the building. The floor space required for the installation of each unit is 32 x 50 ft. and the floor space dimensions of the ultimate power house, as designed, are 34 x 214 ft. The floor-space dimensions of the main building as far as constructed for the accommodation of the present units is 34 x 117 ft.



Plan and Section of Lower Y Branch, with Equalizing Chamber

The alternating-current generators are of the waterwheel type, with the lower portion suspended from the foundation piers within the foundation pit. These machines are designed for a normal constant output of 3500 kw at 500 r.p.m. and 13,200 volts, and they are capable of carrying a 25 per cent overload continuously. Each machine has its exciter direct-connected, the capacity of one exciter being sufficient for two machines when operating at 80 per cent power factor.

In the concrete floor and foundations are laid the electrical conductors from the generator pits, and the leads are accessible at numerous points in manholes and tunnels. The grouping of the leads from the switchboard and switching apparatus is effected in a central tunnel. The switchboard and control station are placed on an extension of the second floor of the annex, projecting as a gallery within the main portion of the building, from which the full interior of the power house proper is visible to the operator. The switching apparatus is located on the second floor and is contained in a series of reinforced-concrete cells. Six lightning arresters are located on the upper floor, and from these the transmission lines pass out through the side of the building, with the usual insulated wall entrances and attachments, which are protected by a 6-ft. awning extension of the roof.

The plant is now in operation and its performance is meeting all expectations. It will be noted that the storage and diversion works, water conduit, forebay, wasteway and the upper third of the penstock system are completed for the full capacity of four units, while the lower two-thirds of the penstocks are completed only for supply to the two of these units now in operation.

The cost of the plant as now constructed figured on the basis of the normal output capacity of the two units installed is less than $70 per horsepower at the power-house switchboard, and the corresponding cost will be reduced to less than $60 when the plant is completed and the output of four units is used. The proportional costs of this plant per unit of capacity as stated are considerably lower than the average cost of such plants, and in fact they will compare favorably with the lowest costs for similar plants. Considering the permanent character of the work throughout, the isolated location of the plant in relation to the material and labor markets and the fact that a great deal of material and appliances required for its construction had to be imported and were subject to heavy customs duties these low costs reflect efficient design and construction.

Equipment

Generators and electrical apparatus were manufactured and installed by the Canadian General Electric Company.

Turbines with governor gear, the relief valves and hydraulic penstock-stop valves were furnished and installed by Escher-Wyss & Company, of Zurich, Switzerland.

Gate valves, 50 and 72 in. in diameter, installed in the penstocks were furnished by the Crane Company, of Chicago, through its branch house in Vancouver, B. C.

Air valves are of the Crispin type; those for outlets up to 4 in. are single units; those for outlets exceeding 4 in. are made in clusters of 4-in. units. These valves were also furnished by the Crane company.

The lock-bar steel pipe, 50 in. in diameter, was made by the East Jersey Pipe Company, of Paterson, N. J.

The power house and hydraulic development constituted a general contract, which has been performed by Grant Smith & Company, contractors, of Seattle, Wash. Briefly, this contract embraced all of the work from the clearing of the land to and including the power house, with the exception only of the machinery and power-house apparatus. The work was begun in the late fall of 1911, and while no unusual difficulties were encountered much delay was caused by extraordinarily high water and inclement weather.

The construction of the plant and installation of the machinery were supervised by the Canadian Collieries (Dunsmuir), Ltd., of which Mr. W. L. Coulson is manager and Mr. Joseph Hunter is chief engineer. They were represented on the work by Mr. L. Netland, resident engineer.

The materials, fittings and structural parts purchased for the power house and hydraulic development were inspected and tested at the various places of manufacture by Robert W. Hunt & Company, under the general instructions of Canadian Collieries (Dunsmuir), Ltd., and the consulting engineers.

Plans and specifications for the work, including the detail working drawings, were furnished by H. K. Owens-A. V. Bouillon, consulting civil and mechanical engineers, of Seattle.

Suggestions for City Engineers

Suggestions for the development of a typical city with regard to buildings, sewers, waterworks, pavements and electrical distribution formed the basis of a paper by Col. H. N. Ruttan, city engineer of Winnipeg, Man., Canada, presented before the recent meeting of the League of American Municipalities. The following notes embody some of Colonel Ruttan's recommendations:

Limits for buildings should be fixed within which only fireproof materials should be used. As the difference in cost between fireproof material and wood is rapidly lessening, the fireproof limits should be ample, including, in addition to business areas, all first and second-class residence districts. All schoolhouses should be fireproof and long, crowded lines of wooden residences should not be tolerated.

Inasmuch as present facilities for passenger traffic have eliminated the necessity for extremely congested centers and high buildings, laws should be enacted to limit the height of buildings and the distances from the street lines. A simple method is to determine the vertical angle at the center of the street beyond which no structure shall project. In residence districts this angle should be sufficiently flat to prevent injury to ordinary dwellings by the erection of massive apartments or tenements.

Sewers

In computing sewer sizes for growing cities full allowance should be made for an extended paved area, as it is much better that the sewers prove too large than too small. Manholes on pipe sewers should seldom be more than 250 ft. apart. On large sewers which can be traversed by men this distance may be increased to 400 or 500 ft.

Flush tanks should be placed at the heads or dead ends of all sewer branches. An automatic type which has quick-flushing capacity and which can be readily turned on and off is recommended in order that the intensity of the flushing may be regulated to suit the requirement of different parts of the sewer system.

Connecting Y branches on both sides of the sewer at intervals of 25 ft. in congested districts will be found to offer all necessary facilities without the necessity of installing new junctions.

A universal meter system is the only sure and economical means of waste prevention. In order to insure the use of sufficient water for sanitary purposes, a flat rate should be charged the consumers for what is determined upon as a sufficient quantity for each size of house, and the meters used to determine excess, which should be charged for at a substantially higher figure than the flat rate.

Pavements

Business and residence districts differ in requirements for pavements. Business streets should be paved full width between the sidewalks and should be capable of carrying loads of 5 tons per wheel. On residence streets full traffic facilities will be afforded by pavements 24 ft. in width, capable of carrying 5 tons on a four-wheeled truck, or a 10-ton road roller. Pavements can be so arranged that under growing traffic they may be readily widened and increased in thickness without harm. Where it is necessary to haul heavy loads through residence districts a heavy traffic road can generally be arranged so that the heavy traffic can be kept off the light roadways. On residence streets the most pleasing arrangement of street improvement is that where the pavement in the center is flanked by two broad grass plots, with the sidewalks on the property lines.

The curbs on street-crossing corners should have radii of at least 15 ft. Broad curves are more pleasing and offer much less obstruction to vehicular traffic than sharp corners.

At sidewalk crossings the pavements should be kept near the walk level; 6 in. or less should be the maximum height of steps. This necessitates the placing of the sewer catch-basins in the center of the blocks, not at the intersections. Of course, these remarks do not apply to steep sidehills.

The system under which the grass and trees on the streets are kept in order by a public department is much to be preferred to any plan which involves the property owners as caretakers.

To avoid crowding and danger it is suggested that in business districts an additional sidewalk at the level of the first story of the buildings be constructed. The protection of the lower sidewalk from sun and weather, the added value for business purposes of the floor at the level of the new walk, and the enhancement of the uniformity and beauty of the streets are also suggested as advantages.

Communication between the two decks would be by stairways or elevators at convenient points and through the business premises fronting on them. Access to buildings at different levels would be by steps or inclines. Protected by a substantial railing on the street side, the upper deck would be an ideal promenade.

While underground electrical distribution is desirable, care should be taken not to extend conduit systems beyond points where the revenue is sufficient to meet the extra cost of this system of distribution. It is estimated that only one-tenth to one-fifth of the distribution area will stand the cost of conduits.

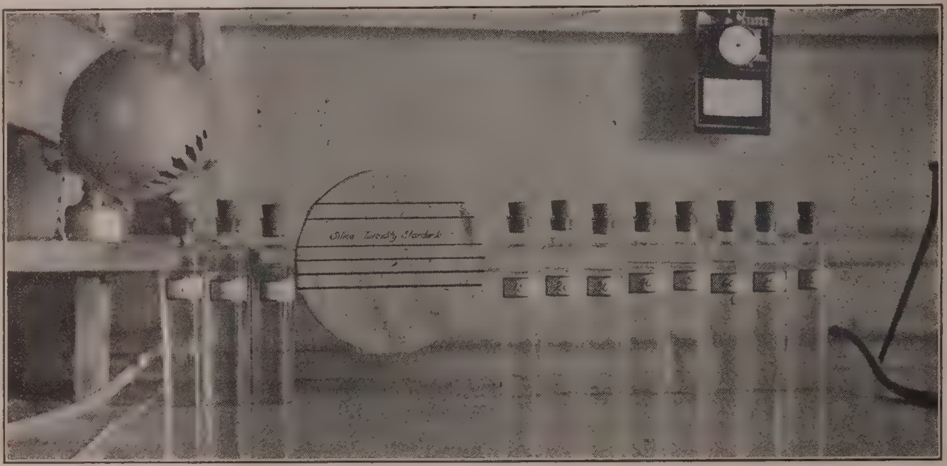
An ideal system in large cities would be to carry the sewers, water and gas mains, electric cables, etc., in large conduits occupying the spaces under the sidewalk. Not only would they be accessible, but this system would put a stop to the cutting up of the street surfaces in making connections and in similar work.

Cement Gun Coating as a protection for metal immersed in sea water has been tested by the Isthmian Canal Commission at Panama. Plates have been coated with ½, 1 in. and 1½ in. of concrete, and after eighteen months' immersion the metal has been found to be free from corrosion.

Reading Turbidity at Night

An ideal north light with which to read turbidity often is not attainable and waterworks analysts have resorted to various expedients to bring out the comparison sharply. Looking through large glass gallon bottles toward a window sash, black and white stripes, a distant tower, a window screen or tinfoil covered corks are some of the methods adopted. In the laboratory of the Denver Union Water Company it is frequently desirable to have readings made at night or late in the day when normal light is not available. This is particularly true of samples on which the filter attendants depend for the adjustment of the chemical regulators, which are readjusted according to a chart plotted from experience for every change of 1 part per 1,000,000 change of turbidity.

By fitting a piece of cross-section paper over an ordinary electric-light cone reflector practically a uniform source of light was obtained. Heavy black lines were drawn across the paper, as the distinctness with which they may be seen is an aid in determining the amount of light cut off by the turbidity.



Apparatus for Reading Turbidity at Night

Some time previous to the use of the cone reflector small 4-oz. oil bottles, which are 1½ in. in diameter and 6½ in. high, were used in place of Nessler tubes to make tests on the small bacterial samples, which were taken much more frequently than the larger chemical samples. After experimenting with the cone reflector and the small standards—which are not so liable to break as the tubes—the large-size-bottle standards have been discarded.

Reduction in Forest-Fire Losses

Forest fires in the States with which the Federal Government is co-operating have not been as dangerous this year as usual, according to a recent bulletin issued by the U. S. Forest Service. This is not an indication of a lesser number of fires but a tribute to the improved efficiency of the fire-fighting forces. Massachusetts and Maine alone have been compelled to call upon the emergency provisions of their agreements with the Federal Government. Maine has found it necessary to exceed the normal allowance, the unusual hazards resulting from long drought prompting the State official in charge of fire protection to employ a large number of men. In Massachusetts an amendment to the original agreement provides for additional expenditures of $500 and $1000 by the Federal and State governments respectively.

Cleaning Streets in Washington

Methods Used Include Hand Patrol, Machine-Broom Cleaning, Squeegees and Flushing

By J. W. Paxton, Superintendent of Street Cleaning, Washington, D. C.

The main requirement for clean streets is careful inspection. With perfect inspection, clean streets can be had under any system if cost is disregarded, but the best system will fail if the inspecting force is inefficient. In Washington, under the contract system, it was found necessary to have with each individual gang an inspector who gave such close supervision that the contractors dismissed their foremen and allowed the inspectors to run the force.

Early in 1911 the Street Cleaning Department of Washington, D. C., was made a division of the Engineer Department, under the direction of the engineer commissioner, an officer of the U. S. Corps of Engineers. Arrangements were made to take over the street-cleaning contracts, the inspectors being sent out as foremen on July 1, 1911, their new duties being practically the same as under the contract system.

Hand Patrol

The hand-patrol or blockman area in Washington, in which 219 men are employed, covers approximately 2,750,000 sq. yd., or 55 per cent of the paved area of the city. The entire area is cleaned daily, and a large portion of it is either squeegeed or flushed about twice a week, weather permitting, no machine brooms being used on hand-patrol areas. This area is divided into six different sections, each having a foreman, two or three wagons, and from 19 to 49 men. The section areas range from 398,000 to 523,000 sq. yd.

Each foreman is given absolue control over the forces under him and is directly responsible to the superintendent for the condition of the streets in his section. The method of working is to divide the entire section into a number of sub-sections or routes and to have one or more blockmen responsible for the streets in their respective sub-sections. The area in these sub-sections ranges from 6000 sq. yd. in the center market to 52,000 sq. yd. in the lightly traveled residential section. The average area per man is 12,000 sq. yd. as compared with 6000 in New York and many European cities. This increase is no doubt due to the frequent washing and also to the fact that Washington has very little commercial traffic or dirt manufacturing plants.

In general, the most economical method of working these sub-sections has been to use two men—one with hand machine and pan and the other with bag carrier. The only two other combinations used in Washington are either a single man with bag carrier and pan or three pan men with two bag carriers. The single-man section is generally composed of lightly traveled suburban streets of considerable area, while the five-man section is used on broad, heavily traveled streets, where the dust must be removed quickly and the gutter length is short as compared with the area.

The amount of dirt removed per day per bag carrier amounts to from 200 sacks during the leaf season to an average of from 10 to 20 sacks at ordinary seasons, each sack holding about 2 cu. ft.

The development of the various sub-sections is the most important duty of the foreman or inspector in charge of a section, the object being to secure a uniform task on each route. For example, the Chicago Efficiency Bureau, under Mr. J. L. Jacobs, finds that it takes 60 per cent more time to clean granite block than asphalt; the combined opinion of eleven street-cleaning district superintendents in New York City gave Belgian as 50 per cent more than asphalt and cobblestone as 300 per cent more. The condition of pavement largely affects the labor required and, from good to bad, is given as 50 per cent more.

Washington Methods

In Washington the practice has been to have the foremen divide their sections into routes. These routes are plotted in the office and criticised, the foreman being asked his reasons for making certain divisions. Suggestions are made as to possible improvements. The foreman is allowed to change his sub-sections at any time, but is required to notify the office and is expected to be ready with reasons for the change. The original maps showing the sections are pasted to celluloid sheets on which the various sections are marked with colored crayon or water colors. This method permits of any number of alterations or erasures without destroying the legibility of the map.

The equipment used in hand-patrol work consists of hand machines, bag carriers and burlap sacks, pushbrooms, pan scapers, sprinkling cans and shovels. The dirt collected is placed in sacks and left at convenient points to be collected and taken to the dump.

Sacks are used in preference to cans because of the weight, bulk and noisiness of the latter, as well as the large number required and the greater difficulty and dust in loading. If jute sacks continue to go up in price, however, cans may be used, for in wet weather a sack sometimes lasts only three or four days.

The hand machines used in Washington consist of two metal boxes mounted on wheels with a revolving bass broom between them. Its action is similar to that of a carpet sweeper and on smoothly paved streets it does excellent work, provided the dirt is not stuck to the pavement, in which case a pan is far superior. In most cases the sections assigned are so large that it is impossible for the men to get the droppings off the street immediately, and pans are preferred to the machines. To overcome this the department has been experimenting for nearly two years with a motorcycle sweeper. This machine is still far from mechanically perfect. It consists of a motorcycle in combination with a hand-sweeping machine, the engine being geared down to 12 miles per hour. Some very good results have been obtained with this machine and a very large area has been covered. No doubt the perfected system of street cleaning will consist of some such machine to work in connection with several bag carriers for collecting the dirt, cleaning gutters, etc., the streets being washed every two or three days.

Machine-Broom Cleaning

The machine-swept area consists of 2,200,000 sq. yd. or 45 per cent of the paved area of the city, the area being almost entirely residential, and each street being swept every other day. The force employed consists of four gangs, each composed of one sprinkler, three machines, four carts and four to seven broomers, depending on conditions in a particular section.

The question of the number of machines to a sprinkler is important and has been the subject of much study and experimenting. The three combinations possible with Washington conditions are one sprinkler to three machines, three to four, or two to five. By experimenting with odometers, thus obtaining the distance traveled, and through the cost keeping, the combination of one sprinkler and three machines has been adopted as the most advantageous, each team covering about 25 miles per day. The one-to-four combination was slightly more economical because of the larger area per sprinkler, but the amount of sprinkling required was more than one team could accomplish without trotting the horses and bringing the mileage up to 35 or 40, the machines still making about 25. On the other hand, the two-sprinkler-five-machine combination gave higher unit costs, while the mileage covered decidedly favored the sprinklers.

In operating a gang the sprinkler valves are not opened continuously but are popped by the driver according to the amount of dirt to be removed, the distance ahead of the machines and the kind of pavement. Much skill is needed in this operation, as too little water causes very heavy dust, while an excess causes a slimy mud which the brooms cannot remove.

Streets are always swept from the center toward the curb, the machines following one another, and overlapping slightly.

In leaf season all machine carts are provided with removable "leaf tops," which are chicken-wire frames of light weight and fit on the flare boards, increasing the capacity of the cart about 2½ cu. yd.

Schedules

The schedules of streets to be cleaned are very carefully worked out in the office so as to prevent any dead travel and to have each street cleaned every other day. Running streets are given from and to the stable for each day, so that the machines work practically from the time they leave in the morning until they return, 85,000 to 90,000 sq. yd., per machine being figured in Washington a day's work. This is considerably in excess of the area reported by various other large cities. The total area of the streets assigned to each gang ranges from 538,000 to 542,000 sq. yd., and the boundaries of each are the result of detailed office study.

The area included in squeegee cleaning comprises a large proportion of the smoothly paved streets in the "white-wing" or hand-patrol section, amounting to about 1,766,000 sq. yd. or 64 per cent of the total white-wing area. At the present time two gangs of one sprinkler and three machines are in operation, each machine covering about 80,000 sq. yd. per day of eight hours, or the entire area being washed in about three and one-half days. During the summer months one gang worked double shift and every street was washed about every two- and one-half days. The above ratio of one sprinkler and three machines, as in the case of machine-broom cleaning, has been worked out by experiment and found to give the best results on Washington streets.

The mode of operation is to have the sprinkler precede the squeegees some short distance and allow the baked dirt to be softened by absorption, the sprinkler throwing as much water as is possible. All the squeegee work being on the white wing section, no special provision is made for the removal of the dirt, the collection being made by the white wings.

Street Flushing

The flushing area comprises all poorly paved and block pavement in the white-wing area, amounting to about 300,000 sq. yd., or 11 per cent., each street being flushed twice weekly by a gang of three flushers. Washington having a comparatively high water pressure, amounting to from 40 to 60 lb., these machines are all of the hydraulic compressed-air type.

The market section of the city is included in the flushing schedule, and in this area, which is probably the dirtiest in the city, it is found that the flusher will clean approximately its own width, each charge lasting about one block of 500 ft. As in the case of the squeegees, it has been found necessary, because of the heavy loads, to use three horses on each machine. At present, each machine is turning out approximately 30,000 sq. yd. per eight hour day.

OILING

During the summer of 1912 five sprinkling wagons were used on approximately the entire suburban area in laying the dust with various oils and patented preparations, each street being treated approximately every ten days. It was found that the cost of this work was slightly in excess of that for sprinkling, but much better results were obtained and the streets were made much easier to keep clean.

Steel Hull of Ferry Erected Twice before Launching

The side-wheel ferry Leschi, which has just been constructed for fast service on Lake Washington at Seattle, Wash., was first erected in the shipbuilding yards on the East Waterway and then dismantled, the parts being moved on flat cars to the shore of Lake Washington, where keel blocks were fitted out on the beach. Although there is only a comparatively short haul between shipyard and beach, it was considered cheaper to erect first at the former point where equipment was conveniently arranged. The shifts of butts on the trusswork were so arranged that it could be taken apart and transported in long sections fully riveted up; and with side tracks within a few yards of shipyard and the erection site at the beach, there was no great difficulty in moving the sections to and from the cars by means of large derricks. About six days, however, were required for taking down the hull as erected in the shipyard.

The ferry has a length of 169 ft., a breadth over guards of 52 ft. 4 in., and a molded depth of 8 ft. 3 in. The hull is subdivided by three athwartship watertight bulkheads and is tied together longitudinally, in addition to the ordinary keelsons and stringers, by a pair of riveted steel trusses extending from end to end. The main-deck beams and superstructure will be of wood, and this part of the work, as well as the installation of the engines, will be done at the beach.

The Leschi will be driven by a pair of inclined high-pressure, non-condensing engines developing about 700 hp and calculated to give the ferry a speed of approximately 15 miles per hour. The boat is being built for the Seattle Port Commission by J. F. Duthie & Co., the contract price being $85,000. Designs for the hull were prepared by Mr. Fred A. Ballin, of Portland, Ore.

THE COST OF CLEANING SEWERS in Hamilton, Ohio, after a heavy flood had packed the channels with débris, was 2¼ cents per foot. The machine used was made by the Turbine Sewer Machine Renovating Company, of Milwaukee, Wis. The cost data were collected by Mr. J. A. Holzberger, Director of Public Service.

Design of Large Bridges, with Special Reference to Quebec Bridge—Part II

Paper by Ralph Modjeski, Consulting Engineer, of Chicago, Presented before the Mechanical and Engineering Section of the Franklin Institute, Philadelphia

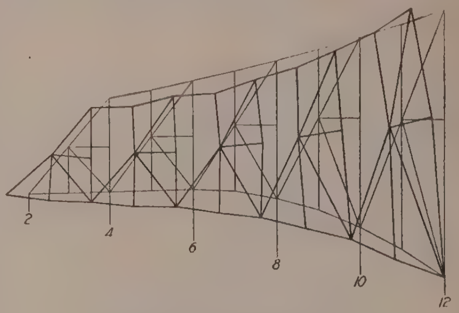
With regard to the distance between trusses and their position relative to each other, the trusses of the new Quebec Bridge will be in two vertical and parallel planes. The distance, center to center of trusses will be 88 ft. One of the first preliminary sketches made after the board was created contemplated placing the trusses in planes inclined in the same manner as in the Forth Bridge, namely, with the tower posts converging toward the top and the bottom chords of both the anchor and the cantilever arms converging toward their respective ends. Another sketch contemplated trusses in vertical planes, but converging for the anchor and cantilever arms toward their respective ends. Both these plans would be economical in the amount of metal required in the finished bridge; but erection of a structure of this magnitude is extremely difficult, and some sacrifice of economy is necessary to make the field work as safe and easy as possible.

It was during the erection that the old Quebec Bridge collapsed. The board consulted several of the best authorities on erection of large structures, and, while their opinion differed somewhat, it was decided, after much deliberation, to make the trusses parallel throughout. In doing so we had in mind not only the erection, which was the principal consideration, but the greater simplicity of details at such important points as the pier posts and the points of suspension of the suspended span. The connections at these points become quite complicated when the anchor arm, cantilever arm, and suspended span trusses are not all in the same plane. It would have been possible to design the bridge with trusses in two planes inclined toward each other, parallel to the axis of the bridge and passing through the end supports of each truss. In this manner all connections of truss members would have been nearly as simple as in the adopted design. Such a design was also suggested and considered. But it was soon decided that the erection of heavy members in an inclined plane of the truss would be too hazardous, and this plan was abandoned.

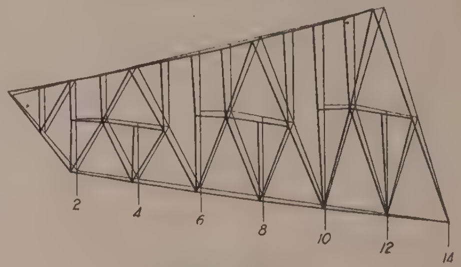
EFFECT OF LABOR CONDITIONS

A question may fairly be asked: Since the Forth Bridge, with its curved bottom chords, inclined and flaring trusses, has been so successfully constructed, why was it not possible to follow a similar design in the Quebec Bridge? The difference is all in the labor conditions prevailing on the two continents at the respective times of building these bridges. At the Forth Bridge 3200 to 4100 men were employed when the work was proceeding full swing; their number attained 4600 for a short period. At Quebec such a large force could not be mustered. The contractors contemplate now using approximately 400 men in the field and not over 1000, including men in the shops. In the Forth Bridge the material was all manufactured at the bridge site. By using a large force of men it was possible to build up the various members of single plates or shapes so that no heavy pieces were handled.

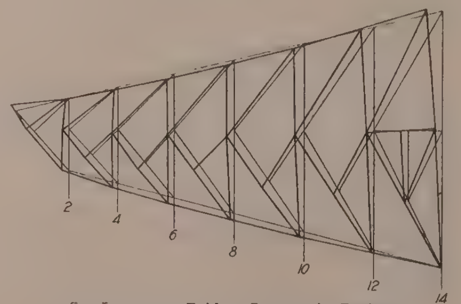
The admirable design, consisting principally of tubes, of which there are nearly 6 miles in the bridge, was built up by employing the method used in building boilers, piece by piece. The connections were laid out in the field, plates bent to suit, drilled and riveted on. This method of procedure would be impossible in Quebec. Not only are the men not available, but while on the Firth of Forth the climate is such that work may go on at all seasons of the year, in Quebec work aloft is impossible during more than seven months in the year. Here, then, the bulk of the work must be done by machinery to save manual labor, and must be done in the shops to permit a continuous progress. The work in the field must be reduced to the minimum or to the assembling of large pieces—as large as it is practicable to handle. The American type of pin-connected construction lends itself best to these conditions, but with that type the details will be much simpler and the erection much easier with trusses situated in two vertical and parallel planes.



Phoenix Bridge Company's Design



Official Design



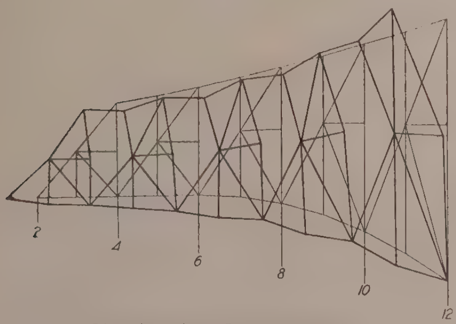
St. Lawrence Bridge Company's Design

Deformation Diagrams of Quebec Bridge

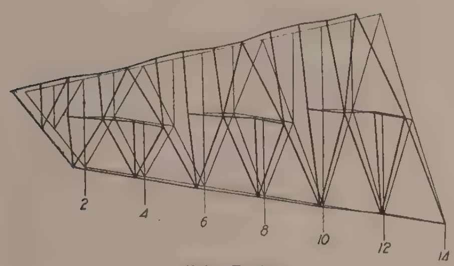
Live load reversed. Scale of deformation is 120 times greater than scale of truss

System of Trussing.—The system of trussing was from the beginning the object of discussion and diversity of opinion among the members of the board; so much so, that before a definite agreement was reached it was decided to work up a plan which, though not satisfactory to all the members of the board, would, when detailed, give the first accurate estimate of weights, which would be also sufficiently accurate to serve as a start in designing any other plan of the same general dimensions. The plan thus detailed, though not approved, will be referred to as the official design.

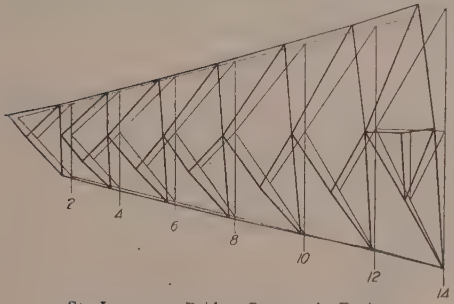
A discussion of the proceedings among the members of the board and the government officials, which led to the ultimate result, would be out of place here. Let it suffice that, in addition to asking for tenders on the official design, the bidders were requested to submit their own designs in accordance with specifications furnished by the board. The time allotted for preparing such designs was shorter than the time it took the board to prepare the official design; but it should be remembered that the official design furnished to the bidders information which it took months of study to prepare. Not the least important information thus furnished was the estimate of weights computed from the details of the official design.



Phoenix Bridge Company's Design



Official Design



St. Lawrence Bridge Company's Design

Deformation Diagrams of Quebec Bridge

Dead plus live load reversed. Scale of deformation is 50 times greater than scale of truss.

Selection of Design.—Several designs were submitted with the tenders; the design submitted by the St. Lawrence Bridge Company, with what may be called a "K" system of trussing in the cantilever arms and anchor arms, was finally recommended by the majority of the board and later endorsed by an enlarged board appointed by the Minister of Railways and Canals for the special purpose of selecting the best tender. The main reasons for recommending the design in question are given in the enlarged board's report as follows: (*a*) The type of design offers greater safety to life and property during erection, as well as economy and rapidity in construction. (*b*) The design contains the minimum number of secondary members and requires few, if any, temporary members during erection. (*c*) The system of triangulation, by dividing the web stresses, reduces the members to more practical sections and simplifies the details of connections. (*d*) The design economizes material, as shown by the calculated weights of the two designs. (*e*) The general appearance of the structure is, in our opinion, improved.

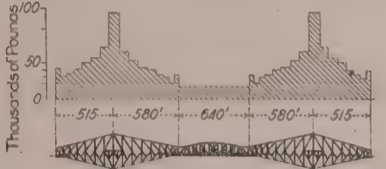
Uniform Deflections

There are two advantages of this "K" design which are not clearly brought out in the above reasons, and on which I wish to lay considerable stress, namely, uniform deflections and regularity of erection operations from panel to panel. The uniform deflections can best be seen by comparing the Williott's diagrams which show the deflections of the anchor arm under dead load and under dead and full live load in the old, the official, and the final designs. The deformations are, of course, on an exaggerated scale. A comparison of these diagrams will show that secondary members, or those which receive their maximum stress from partial live load only, such as the vertical suspenders carrying one panel of floor, or members which carry dead load only, such as vertical sub-posts supporting the top chord, or members which normally have no stress in them, such as struts which serve to reduce the unsupported length of main compression members, are the source of local bending in the main members to which they connect. This is because the variation in length of the secondary members as the loads are applied is independent of the variation in length of the main members. For instance, a secondary member carrying dead load only receives its full deformation in length when the span is finished, but its length remains constant under any condition of live load, while the adjoining main members compress or elongate with each application of live load. In the same manner a suspender carrying one panel of the floor, for instance, will receive its maximum elongation under concentrated live load in this panel whether the remainder of the bridge is loaded or not, while the adjoining main members will receive their maximum deformation under quite different conditions, of loading. The bridges are generally designed in such a manner that the secondary stresses are either entirely eliminated or largely reduced when the main members are subject to greatest direct stresses. This is done by determining the lengths of the various members, both main and secondary, in such a way that the truss, under the maximum load, will assume as nearly as possible the geometrical shape. This requires, however, an initial displacement of the main members, which during erection may be very objectionable.

The diagrams referred to show the situation as reversed, namely, as if the loads were applied to a truss having the true geometrical form. In order to obtain the true geometrical form, after the loads are applied, we should begin with a truss deformed under condition of no load.

The comparatively large distortions of the truss in the old design are due not only to greater unit stresses used but also to the curved bottom chord and the large number of secondary members. I have explained the reason why curved bottom chords were used in that design. Of the three designs shown in the diagrams, the new design has the least number of secondary members. It should be remarked that the same advantage could have been obtained with a double intersection Warren truss by arranging the panel lengths in such a manner as to eliminate the intermediate vertical secondary members supporting the chords. (See Memphis and Forth Bridge diagrams on insert sheet supplement to Engineering Record, Sept. 20.) It would be interesting to know the extent of secondary bending stresses produced in the tubular bottom chords of the Forth Bridge by those vertical members, but unfortunately the necessary data for their calculation are not available.

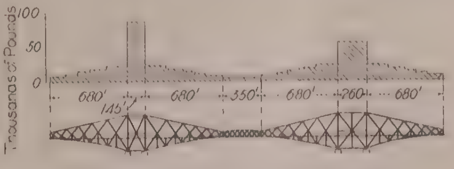
The regularity of erection operations consists in the fact that, starting from the pier, the position of members in each panel in the "K" design is just like the preceding one, and that coupling up of members in each successive panel, as the traveler moves forward, requires the same succession of motions as in the preceding one, except that pieces become lighter as the erection proceeds. Experience shows that the oftener an erection crew goes through a series of the same motions, as, for instance, in erecting a succession of simple spans all alike, the more rapid their progress becomes.



Weight per Foot of New Quebec Bridge

Features of Quebec Design

Some of the more important features of the Quebec design will be of interest. The lateral wind-bracing has been omitted between the top chords of the cantilever and anchor arms. All wind forces are taken directly to the pier through substantial bracing between the bottom chords. This arrangement not only makes the distribution of wind stresses perfectly definite but permits the spreading of tracks to 32 ft. 6 in., center to center, instead of the usual 13 or 14 ft. which results in a saving in the floor system, and consequently in the entire structure. With the tracks spread, a load on one track only produces a torsion in the cantilevers, and the presence of wind-bracing between the top chords would produce undesirable and excessive stresses which would have to be taken care of by a large addition of metal to the lateral and sway systems and to the trusses.



Weight per Foot of Forth Bridge

The floor system is of carbon steel throughout. It is, therefore, stiffer than if made of nickel-steel. The long floor beams deflect less and the secondary stresses produced by their deflection are thus reduced. Even then some of the connections of floor beams to posts had to be made by means of pins. The top chords of the cantilever arm and of the anchor arm as now designed are of carbon steel eyebar. The originally submitted design contemplated nickel-steel plates riveted throughout for the cantilevers, and carbon steel plates for the anchor arms. By substituting eyebars a better design is obtained and much easier erection assured, and, although nickel-steel is replaced by carbon steel in the cantilever arm, the substitution results in a saving when both the cantilever and anchor arms are considered. Carbon steel will be used in the entire anchor arm, in the top chord and pier members of the cantilever span, in the top lateral system of the suspended span, in all the floor system and in all sway bracing. Nickel-steel will be used in the trusses and bottom laterals of the suspended span, in the trusses except top chords and pier members, and in the lateral system of the cantilever arm. The anchor bars which hold down the ends of the anchor arms have been made very long to reduce bending stresses from expansion.

The suspender eyebars which support the suspended span are subject to oscillation in the plane of the trusses, due to expansion. A total expansion of 16 in. must be taken care of at these two points of suspension, besides the extension of the bottom chords under the live load. Manganese bronze bushings will be provided in these eyebars to permit of easy turning on the pins. But, even should these fail to turn, there is sufficient metal in these eyebars to prevent overstress from bending.

Friction brakes will be installed to prevent excessive longitudinal oscillations of the suspended span under tractive forces of trains.

All latticing of compression members is designed in proportion to the sectional material of each member. The latticing is made strong enough to transmit in transverse shear 2 per cent of the direct stress of the member.

Determination of Dead Load

After the designer has determined the principal dimensions and has designed the skeleton outline of the bridge, the next necessary step is to calculate the stress sheets and proportion the various members. Assumptions must first be made on the dead load of the various portions of the span. In simple spans and in suspension bridges a first assumption of a uniform load per foot is generally sufficient except in very long spans, in which the concentrated loads should be calculated after the details are designed, and the sections should be checked and modified if necessary. In cantilever structures the distribution of the dead load is quite far from uniform.

The Forth Bridge weighs 2 tons per foot at the center of each span and 13½ tons per foot near the towers. The new Quebec Bridge weighs 8.7 tons per foot near the center and 38 tons per foot near the piers. The original Quebec Bridge was underestimated—the calculated dead load stresses were too small; it was to guard against a similar error that the official design of the new bridge was worked out in detail before even the system of trussing was quite agreed upon.

In calculating the weight of a span from the known weight of a shorter span it is customary to assume that the total weight of steel in trusses and bracing increases as the square of the span. This rule of thumb is sufficiently correct for small spans, not to exceed 200 or 300 ft. in length, but is obviously wrong for very long spans. If it were true for all spans, then a span 10,000 ft. in length could be built by providing 100 times more metal than a span of 1000 ft. would require. We know that a span of such length is impossible with materials now known and that it would fail under its own load. As a matter of fact, in a cantilever system of the size of the Quebec Bridge the weight of the steel increases more rapidly than the cube of the length. This power or exponent increases still further for longer spans until it becomes infinite for a span which is just long enough to carry its own weight only at the allowable unit stresses without being able to carry any live load.

The principal dimensions being fixed and the preliminary stress sheets calculated, the details of the structure must be worked out. Needless to say that all these determinations which I have mentioned as taking place in succession are correlated to each other, and frequent retracing of one's steps is necessary before the detail plans are matured. The general order of procedure, however, is always about as described.

(To be concluded.)

Erecting a One-Piece Wooden Flagpole 208 Feet Long

The erection of a Douglas fir flagpole in front of the provincial courthouse at Vancouver, B. C., has presented unusual features because of the desire to use a long, single stick, representative of the timber resources of the province, and to so place it that its base would be secure from decay. Accordingly, a suitable timber was cut and delivered in the rough at the courthouse in the fall of 1912. It was supported in a horizontal position on blocks placed about 15 ft. apart and left for a year to season where there would be no likelihood of its curving while drying. During the seasoning it was turned frequently, worked with a draw-knife, and finally given several coats of paint. The pole is circular in the upper section and hexagonal at the base.

Raising One-Piece Wooden Flagpole, 208 Feet Long, at Vancouver

In September, 1913, it was moved on rollers to its final location, the center of gravity of the pole being placed adjacent to the foundation pit. The foundation consists of a concrete block below ground, 12 ft. square and 12 ft. deep, in the center of which a square hole 3 ft. wide and 9 ft. deep was provided to receive the lower end of the pole. This hole was lined on sides and bottom with galvanized iron 3/16 in. thick, to exclude moisture. The metal casing was built up in the shape of a tank, slightly smaller than the hole into which it was lowered and secured in place by pouring grout around it. The walls of this metal casing extended above ground far enough so that after the pole was in place they could be bent inward, the edges sunk into the wood slightly and all four sides soldered together so as to shed water. The casing was made of such size that when the pole was in place there was a 3-in. space all around between pole and casing. This space was filled with dry sand, tightly packed and protected from the weather by having the metal top closed immediately after the pole was set.

The flagpole is 208 ft. long, 36 in. in diameter at the base and 10 in. at the top, and when ready for erection weighed about 10 tons. A derrick with an 87-ft. mast was used for erecting the pole, to which the hoisting cable was attached just above the center of gravity, as determined by trial. As a safeguard against bending stresses during erection, four small cables were run lengthwise of the pole on opposite sides and were thrust outward at the mid point by struts to bring them up taut. After a few preliminary pulls to try out the tackle, the pole was raised without any difficulty, was set in the metal casing and then lashed to the derrick mast until guy cables could be attached.

The guys are eight in number, four being attached at a height of 108 ft. and four at 166 ft. Four blocks of concrete 8 ft. square and 8 ft. deep are provided for anchoring the guys, one guy from each of the two girdles running down to each concrete block. Surmounting the pole is a 4-ft. globe and a 20-ft. weathervane in the shape of an arrow. The vane is carried on a shaft let into the pole a distance of 3 ft., revolving on brass bearings. Globe and arrow weigh about 500 lb.

The work of erecting the pole was done by McDonald & Wilson, of Vancouver, under the supervision of Mr. E. Bickerton.

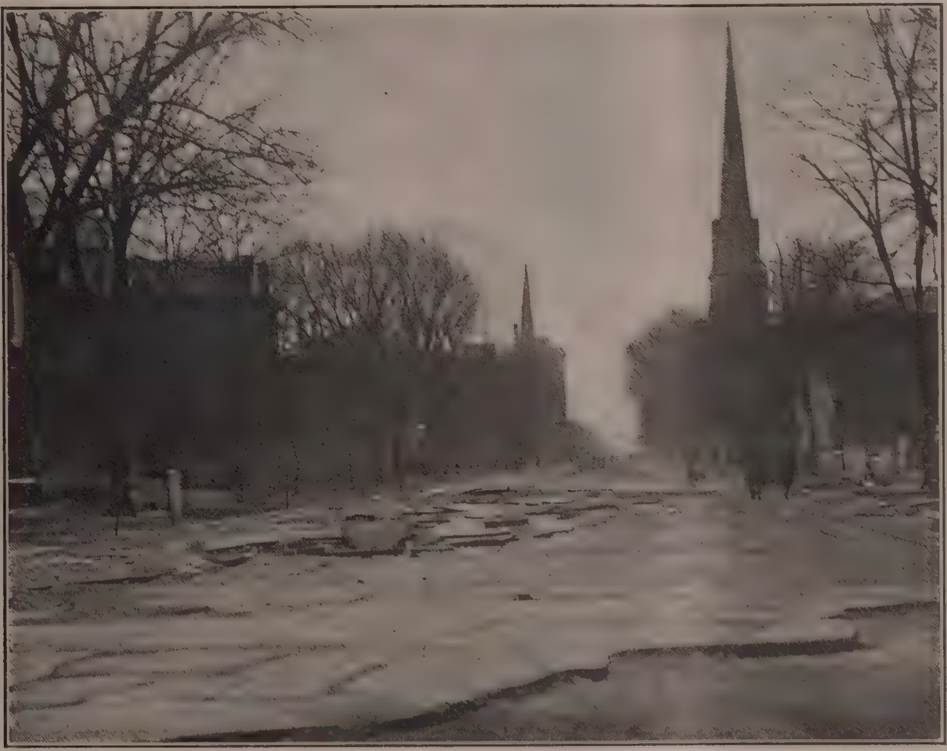
Testing Wooden Poles

Tests of wooden poles reinforced at the ground line with concrete collars were recently conducted by the Pittsburgh Reinforcing Pole Company to determine the effectiveness of its Orr reinforcing collars. Five 40-ft. and ten 30-ft. chestnut poles and ten 30-ft. cedar poles were tested. In the first test the cedar poles broke off above the collar at an average pull of 2000 lb. and the chestnuts at an average pull of 3000 lb., the load being applied 30 ft. above the ground on the 40-ft. poles and 19 ft. on the shorter ones. In almost every case cracks developed in the concrete collar at 1500 lb., although the ultimate strength was satisfactory. For the second test heavier collars were used, and five of the 40-ft. poles withstood an average pull of 2335 lb. before developing any cracks in the collars, six 30-ft poles withstanding 2444 lb. in a similar manner.

Effects of Flood on Pavements and Sewers

Notes on the Damage and Repair of Municipal Works at Dayton

By Gaylord C. Cummin, C.E., Former City Engineer of Dayton



Asphalt Paving on Ludlow Street Damaged by March Flood

The flood of March, 1913, with from 6 to 20 ft. of water in the city, developed some very high velocities in the streets, which led to forms of damage to street pavements not often encountered. The greatest damage occurred on those streets paved with sheet asphalt, of which there were many miles within the flooded area. This pavement consisted of a 6-in. concrete base, 1-in. binder, and 2-in. wearing surface, a few of the oldest streets having a 1-in. sand cushion in place of the binder. The pavement laid during recent years suffered little or no damage, but a number of streets that were laid from twelve to sixteen years ago, especially where subjected to heavy traffic, were practically continuous patchwork, with but little of the original pavement remaining. The water succeeded in getting between the wearing surface and the concrete foundation, especially where holes had developed since last season's repairs, and in some cases the strong currents ripped up the whole surface for several blocks, scattering the pieces over the streets several hundred feet from their original position. Pieces from 15 to 20 sq. yd. in area were moved from 200 to 300 ft., and in some cases turned over, piled one on another, and carried upon sidewalks.

The pavement appeared to break at the joints between patches, the unpatched pavement suffering very little. Some of the patchwork was first class, but much was burned and dead, and in many instances no binder had been used. The burned asphalt broke and crumbled into small pieces, but the better work remained in large sheets and showed considerable tenacity, many sheets being bent 30 deg. on a 6-in. radius without fracture. The accompanying illustration gives a good idea of the destructive effects on these pavements.

A careful examination was made of all the asphalt streets in the flooded district, and it was ascertained that asphalt streets, where the surface had been in good condition and without holes at the time of the flood, were not injured, even where the velocities had been very high; but where there were holes in the surface even comparatively low velocities resulted in almost complete destruction. The concrete foundation did not suffer any appreciable damage, although some patching will be necessary because of traffic on the concrete since the flood and before the resurfacing was complete. The total area of surface that will have to be replaced as a result of the destructive effects of the flood exceeds 30,000 sq. yd.

By far the greatest number of streets in the flooded area are paved with vitrified brick, using a grout filler. These were only damaged where the foundation was undermined by some local vagary of the current, the total damaged area not exceeding 1000 sq. yd.

There were two macadamized streets in the flooded district, one being adjacent to a bad washout in the levee. This last-mentioned street was badly washed and must be reshaped and given a new top dressing.

The few stone-block streets were not injured at all, although old and in poor repair. There is no wood block in Dayton, and the only bitulithic pavement was not in the flooded district.

Sanitary Sewers

Storm and sanitary sewers came through the flood in remarkably good shape. The sanitary sewers empty into the Miami River at four points in the southern part of the city. At two of these outfalls it is necessary to pump the sewage into the river when the stage exceeds 9½ ft. For this purpose two pump stations equipped with electrically driven centrifugal pumps are employed. Ejectors, run by compressed air, furnished through pipe lines from the city waterworks, are used in the low parts of North Dayton and Riverdale to lift the sewage so that it can flow by gravity through inverted siphons under the river into the main sewers in the central part of the city. The sewers themselves were practically all found open when the water receded, no stoppages of any importance occurring. The pump stations were flooded and the electrical machinery was ruined; and as the river maintained a high stage, and rose above 9½ ft. during the next week, temporary suspension of the sewers tributary to these outfalls was necessary. The air lines to the ejectors were destroyed, and the ejector pits were filled with mud and gravel. The sewers in North Dayton and Riverdale were therefore by-passed into storm sewers and discharged direct into the river. The St. Francis outfall was blocked by the ruins of an undermined manhole, and some trouble was experienced in opening this on account of the high stage of the river.

Except for the temporary interruptions due to high stages of the river, all of the sanitary sewers, with the exception of those in the small St. Francis district, were in full operation within three days of the receding of the waters. Some stoppages occurred in the mains and laterals, but these were promptly opened as soon as reported. The St. Francis outfall was cleared within a week, and the receding stage of water in the river permitted the operation of the whole system. The damage done to the sanitary sewers by the flood consisted of the ruining of the motors and switchboards in the pump stations, the motors needing rewinding and the switchboards general overhauling; a few unimportant washouts on laterals and the loss of manhole covers and the like. Since the flood a great deal of trouble has been experienced with stopped-up house connections, and outside of the injury done the pump stations, this is the most serious damage done to the system.

Storm Sewers

The storm sewers required much more attention than did the sanitary sewers. Practically every one of the sixteen hundred catchbasins in the flooded district were filled to the top with mud and débris. Manhole and catchbasin covers were lost, and a few sewers with a very flat slope were so choked with mud that a thorough cleaning was necessary. Two pump stations of similar design to that of the sanitary system, situated in Riverdale and North Dayton, were flooded and suffered the same fate as those of the sanitary system.

The flooded area was divided into eight districts, and lists of the catchbasins with their locations were made. Gangs of five or six men, furnished with a list of streets where the basins to be cleaned were situated, were started the Saturday after the flood. In these eight districts there were basins of all types, all of which were inspected, and as many cleaned as possible with the equipment at hand. Those not cleaned at first were reported and cleaned when proper equipment was secured. Within a week all the basins in the flooded district were cleaned with the exception of about forty, which were practically mere inlets, and were stopped up in the connection pipes leading to the manholes. The forces engaged in this work labored under great disadvantages from want of proper equipment and because many basins had to be dug out from a mass of débris. Many basins in the business district had to be recleaned as many as four times in ten days, due to the pumping out of cellars and the flowing of the nearly liquid mud that covered the streets into the basins, in spite of the placing of planks over the openings in an effort to exclude as much as possible. The sewers that required cleaning were cleaned as soon as possible, the river valves inspected, and any damaged parts replaced, and except for the pumping stations, the storm sewers were in full operation within two weeks of the time work was started.

Street-Cleaning Problems

There were several rather unique problems in street cleaning presented by the mass of mud and débris left by the flood. The receding waters left a deposit of from 4 to 6 in. of river silt over everything in the flooded district, and in addition the streets were encumbered with all sorts of refuse. As the business houses were cleaned, their contents of mud and damaged stock were dumped into the street, making probably the most miscellaneous collection of litter that ever encumbered the streets of an American city. The task of removing this with despatch was one of the most pressing tasks after the flood. Dumps were located in different parts of the city, and all the men and teams that could be secured were set to work on the less encumbered streets, but the worst streets needed more effective methods.

Temporary connections were made between the steam-railroad and the street-railway tracks, and the railroads furnished flat cars that were handled by a light switch engine, a dinkey engine, and the National Cash Register Company's industrial locomotives. When these engines were not available and it was necessary to move the flats, either a motor truck or a steam roller was pressed into service. These cars were run on the principal streets and loaded by shovelers, steam shovels being used on the worst streets. A road scraper pulled by a steam roller was used to aid the shovelers, and material was also brought to the cars by teams where there was no dump available within a short distance. The cars when loaded were taken out of the city along the railroad and unloaded by men detailed for that purpose.

Traction Engine and Road Scraper for Cleaning Dayton Streets

Engineering Appraisements of Waterworks Properties

When a water company begins to render poor service it is not long before there arises among the consumers a general demand for a readjustment of rates. This was the case at Chillocothe, Ohio, where the fire protection was inadequate, and at Texarkana, where water of an inferior quality was being furnished. In both instances Mr. Philip Burgess, consulting engineer, of Columbus, was detained to examine and appraise the properties and advise as to a new basis for charges. The results of his experiences in this field of valuation were embodied in a paper, of which an abstract is given below, presented before the Central States Waterworks Association on Aug. 27.

Four methods are used for valuating waterworks properties:

1. A determination of the original or book cost as indicated by actual past investments, without allowances for depreciation or appreciation. To this value should frequently be added, for comparative purposes, the deficits in revenues below all necessary charges incurred during the early history of the plant.

2. A determination of the cost of reproducing new the existing property at costs based upon present nominal prices for material and labor, corrected for depreciation resulting from age and usage. This method necessitates studies of all values which may affect the worth of the plant as a going concern.

3. A determination of the value of the plant as indicated by the market value of its securities, especially when there exists a representative market.

4. A determination of the commercial or comparative value of the plant. Such a value properly would be considered by a tentative investor, especially if he were without detailed knowledge of construction costs.

Unfortunately the past or book costs of waterworks properties frequently are not available in reliable form, especially as regards replacements and extensions. It is not uncommon to find no plant account carried on the books and no distinction made between maintenance and depreciation, or between maintenance and true operating costs. It is the exception to find a waterworks account in which depreciation is properly cared for.

It is the exception to find a representative market of the securities of waterworks properties. In the majority of instances where plants have been established for a number of years the face value of the securities has little if any relation to the cost of the plant, so that it is an unusual instance when this method of appraisement is of value.

Depreciation

Because laws frequently require appraisements of the cost of reproduction new the latter method is most frequently used in determining the valuation of waterworks properties. The cost of reproduction new must be properly depreciated to determine the present worth of the plant. This also requires of the appraiser that he study carefully the life, age and present condition of the component parts of the properties and that he determine the average life and rate of depreciation of the plant as a whole. Subsequently he may assist his judgment by considering general data on the life and depreciation of similar structures in tables prepared by authors of experience. Judgment and experience are here required of the engineer, because no two plants have the same component parts and because the proportions of equally depreciable parts vary in different plants.

In applying the method of reproduction new to property it is necessary to assume the beginning of the construction of a comparative plant under the data of the appraisement. The unit prices assumed by the engineer in constructing his imaginative comparative plant are a very important element of the final result obtained. Some of the parts vary materially in cost from time to time, as in the case of cast-iron pipe and trenches. Such other elements as valves, hydrants, pumps and boilers are of more uniform cost. It is customary to base the cost of reproducing cast-iron pipes on past costs for a period of five years preceding the date of valuation. The costs of pipe required for extensions made from time to time have little value in determining the cost of reproducing new, as they are often bought in small lots and not at carload prices.

Preliminary costs, such as interest during construction, engineering, supervision, and contingencies, are generally estimated as a certain percentage of the total cost of reproducing new the physical plant. Such costs are often estimated at 10 or 15 per cent. They should, of course, be determined upon the total cost of reproduction new and not upon the present worth after allowing for depreciation.

Having determined the total cost of reproduction new, including preliminary costs, the next feature is to determine the proper allowance for depreciation. This determination requires an estimate of the probable life of the component parts of the plant. From these the average life of the plant as a whole may be readily determined.

The depreciation fund should represent at all times the difference between the investment and present worth of the plant. Moreover, the annual contribution to the depreciation fund, placed at compound interest, should be of an amount such that the depreciation fund accumulated during the period of the life of the plant as above estimated will equal the cost of the plant.

An important element, therefore, to be considered by the engineer in determining the amount to be contributed annually to the depreciation fund is the rate of interest which that fund should yield. It has been argued that such funds in the past have been used for extensions and that, therefore, the rate of interest on the depreciation fund should be considered as that allowed for a fair return on the entire investment. If, however, the depreciation fund is to remain intact, a savings-bank rate of interest at from 3 to 4 per cent appears fair.

Mr. Erickson, chairman of the Wisconsin Railroad Commission, stated last year that the average ratio between cost of reproduction new and the present worth of twenty-three waterworks plants, as determined by the engineers of that commission, was 91 per cent. The maximum was 94.6 per cent and the minimum was 84.6 per cent.

Going Value

Having determined the present worth of the plant, the engineer must decide what additions properly may be included to give the entire valuation of the works as a going concern. Again there is a considerable difference of opinion among engineers as to the method of estimating what is commonly called the "going-concern" value, for while the courts have recognized such a value they have not determined how it shall be estimated. Three methods are commonly used.

The first method is to figure going value as equal to the cost of developing the income of the present plant during its early history. The books of the water company, where available, generally indicate deficits during the first few years' operation of the plant. Such differences between the revenues and total costs of operation, including allowances for interest and depreciation, may be classified under "development cost" as distinct from "going value." For comparative purposes the development cost should be included in the book cost of the plant. It properly has no relation to the cost of reproduction new.

The second method considers going value as the cost of developing the income of an imaginative comparative plant exactly like that in question, the construction of the comparative plant to begin on the date of appraisement.

A third method involves a measure of the added value of the physical plant due to the fact that it is a going and not a dead concern. This would seem to be on the basis that the "present worth" of the physical plant may be considered greater than that obtained from the cost of reproduction new corrected for the usual allowance of physical depreciation, and that the present value of the plant is more nearly that of the cost of reproduction new. In other words, it is recognized that the physical plant may have a value to the company greater than its depreciated reproduction cost, because the plant may be just as capable of giving first-class service to the public as it would be if it were absolutely new. This theory has been carried so far by some engineers as to lead them to say that the value of a plant for ratemaking is the cost of reproduction new, and not the present worth as obtained by making allowances for depreciation and adding thereto a certain amount to represent the going-concern value estimated as a separate, distinct item.

Continuation of Louisville & Nashville Improvements in Eastern Kentucky

Features of Reconstruction and New Construction from Irvine East

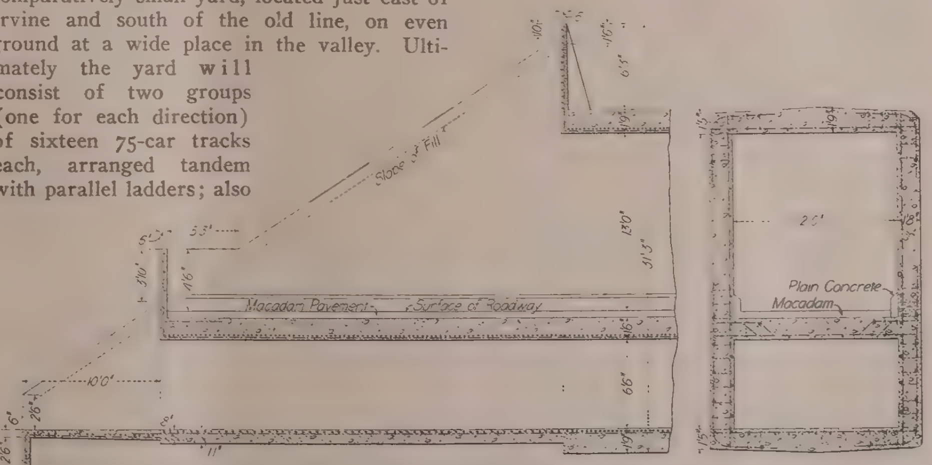
In the construction of new lines and the adaptation of old lines of the Louisville & Nashville Railroad to the economical handling of coal from the fields in eastern Kentucky, the work from Irvine, the southern terminus of the new Winchester-Irvine line already described in this journal, to Beattyville, a distance of 34 miles, consists chiefly of the filling of bridges and trestles, the widening of cuts and fills, and the construction of Irvine yard. Two miles east of Beattyville, at Maloney, the present line turns to the north and follows the North Fork of the Kentucky River up about 3 miles to a junction with the Lexington & Eastern Railway, now controlled by the Louisville & Nashville. The Lexington & Eastern in turn comes down the other side of the North Fork to the Middle Fork, the windings of which it follows up to Tallega. A new line about 5 miles long under construction from Maloney to Tallega will cut off about 7 miles. From Tallega the improvement extends 3 miles farther, to Athol, the work on this section being grade and alignment revision.

Irvine Yard

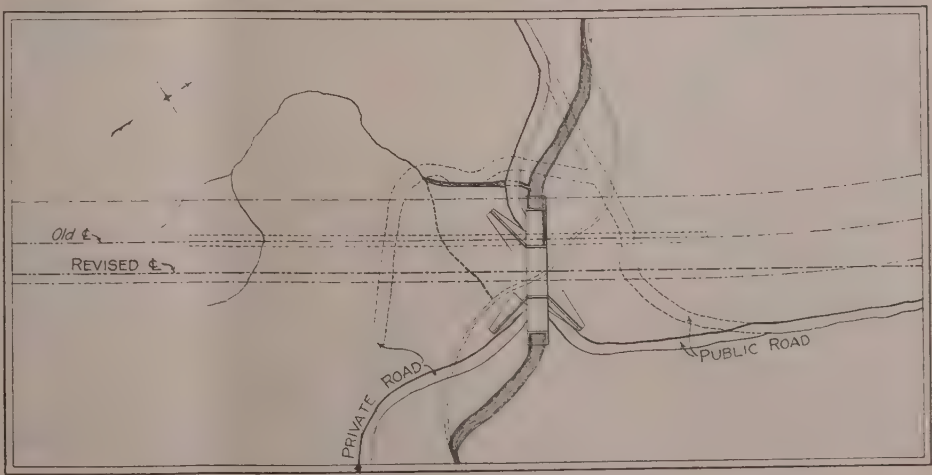
Irvine yard is being built for the double purpose of creating a convenient division point for coal trains from the mines at the southern end of the Lexington & Eastern, and providing suitable junction facilities between the new line to Winchester and the old one through Richmond. It will be a comparatively small yard, located just east of Irvine and south of the old line, on even ground at a wide place in the valley. Ultimately the yard will consist of two groups (one for each direction) of sixteen 75-car tracks each, arranged tandem with parallel ladders; also a repair yard and an engine terminal. For the present the more westerly group and several tracks of the other group will not be built, being unnecessary for present traffic conditions.

For a large part of the area of the yard the grading is light for the locality. The excavation will make more embankment than is needed for the immediate construction, but use is being found for it in the fill for the future extension. The location selected for the engine terminal is on the south side, toward the east end, on the site of a hill that conforms closely to the exterior line of the engine house. The hill is mostly rock, providing a good foundation for the engine buildings, and the spoil, which is being taken out with a steam shovel, and handled with narrow-gage service equipment, is all being utilized. The engine house will have ten stalls, and ten other short uncovered engine tracks will radiate from the turntable.

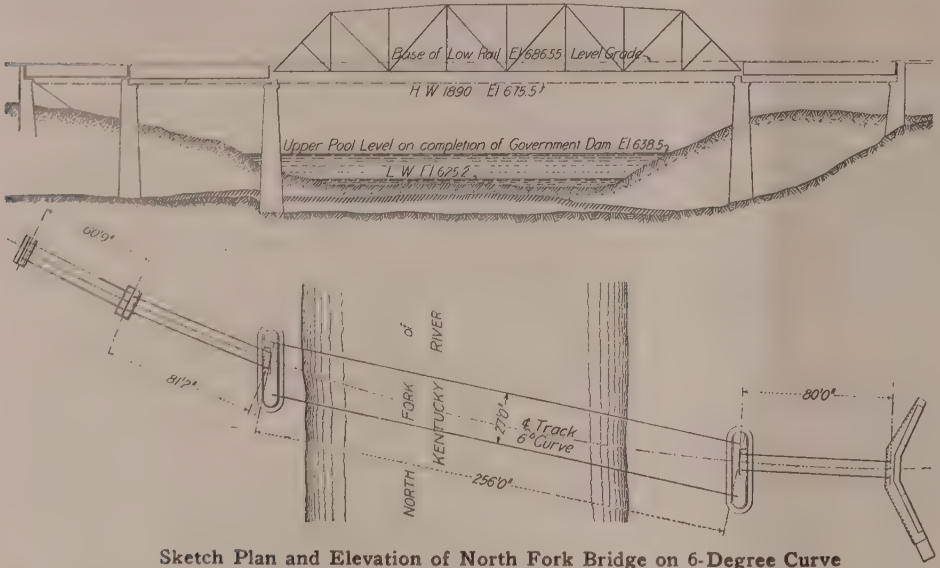
The yard as located fouled several public roads, and in order not to damage the community in that respect a new highway is being built each side of the yard for its full length, with a new crossing at the east end. As the grading proceeded, two small private graveyards were encountered on the south edge of the yard. Although there had been no burial in one of the plots for at least



Transverse and Part of Longitudinal Sections of Double-Deck Culvert

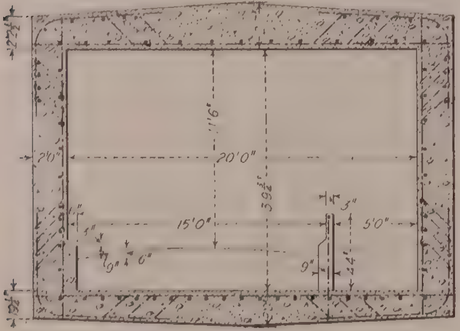


General Location Plan of Double-Deck Culvert at White Ash Creek


Base of Low Rail El 686.55 Level Grade
H W 1890 El 675.5
Upper Pool Level on completion of Government Dam El 638.5
L W El 625.2
60'0"
81'0"
NORTH FORK of KENTUCKY RIVER
27'0"
℄ Track 6° Curve
80'0"
256'0"

Sketch Plan and Elevation of North Fork Bridge on 6-Degree Curve

fifty years, the laws of Kentucky are such that it was deemed inadvisable to attempt to move the graveyards. Their location was such that it was found that by moving the entire paper location of the yard some 300 ft. to the west, keeping the one curve in the middle of the yard in its original location, the burying grounds would be avoided; and this was done.



Cross-Section of Subway at Beattyville

WHITE ASH CREEK DOUBLE CULVERT

About 1½ miles west of Beattyville the old line crossed White Ash Creek, a highway and a private road on a trestle 400 ft. long. In order to get rid of the trestle and provide the necessary crossings, at the same time keeping the roads above the pool elevation established by the Federal government by the construction of a dam in the Kentucky River near by, the double-track reinforced box culvert shown was designed. As the illustrations indicate, the waterway at the bottom is 12 ft. wide and 6 ft. 6 in. high. The roof is 1 ft. 6 in. thick, and is covered with a 6-in. layer of macadam, forming a roadway the same width as the waterway, with 13 ft. clear headroom. The waterway section extends far enough at each end to allow the roadways to turn off, and a parapet 4 ft. 6 in. high surmounting each end of the waterway roof insures against driving off the end.

A short distance east of the point, on a relocation that avoids a detour around a hill, saving about 1000 ft., Myra Branch is crossed with a 6 x 8-ft. floating box culvert. To keep the top of the culvert above the government pool elevation previously mentioned it was necessary to locate the opening part way up one bank of the gully. Outcropping rock indicated that a solid support would be found for the entire culvert. When the excavation was made, however, there was encountered between the hard rock at the ends a soft place about 16 ft. long at the inner side and 100 ft. at the outer side.

It was imperative that no time be lost, as the contractor was dependent upon the new culvert to get his steam shovel across the ravine within a short time. With a spacing of from 10 to 12 ft., 10-in. well casing was driven to solid rock along the center line of each culvert wall, and was then filled with concrete. Only one of these concrete piles was needed on the side next to the bank, but eight were used along the outer side. Extra reinforcement was used in the floor over the piles, and no trouble has been experienced.

Excavating Approach for New Mud Tunnel alongside and below Old Tunnel

From Maloney, where there are heavy cuts on the main line and the wye, the principal features of the cut-off to Tallega are the two bridges over the North and Middle Forks respectively of the Kentucky River, on neither of which much has been done. Between them the grading is mostly comparatively light sidehill work. The Tyler tunnel, 725 ft. long, involved no special difficulties. The chief feature of it is its location. The west approach cut is practically nil, being located at a sharp elbow in the river. At the other end fairly heavy grading was necessitated for about 3000 ft., to the point where the line rejoins the river. Thus in less than ¾ mile a loop in the river approximately 3 miles long is eliminated.

NORTH FORK BRIDGE

The general plan and elevation of the North Fork bridge are shown. It will be noted that the track will be on a 6-deg. curve with 3¼-in. superelevation, and that the main-span piers will also be skewed with the span. It was originally intended to use three spans only, but it was found that if the U. S. government should build the dam proposed at Beattyville the water would endanger the slopes around the west stub abutment. It was therefore decided to make this abutment a pier and put in another short span, utilizing a bridge taken out elsewhere.

Nature of Rock at Old Mud Tunnel

The Middle Fork bridge will be 400 ft. long and 80 ft. high above low water, with five spans. From this bridge to Athol heavy grading is encountered. The north approach fill is 800 ft. long and 50 ft. high, involving 115,000 cu. yd. It shoots off practically at right angles to the Lexington & Eastern, which curves sharply around a hill. Ultimately the new embankment will cross the old line 17 ft. above it and strike deeper into the hill, the spoil from which will go into a ravine just beyond. For the present, however, the material is being brought down alongside the main track from a cut farther east. Few passenger trains are run over this line, and therefore it is permissible to utilize the main track for work-train service where to do otherwise would involve much expense. Therefore the narrow-gage track cuts into the other and uses it by means of a third rail for some distance.

East of the Middle Fork crossing the old as well as the new line leaves the river, reaching a summit at Mud tunnel, a distance of 1½ miles. The old tunnel was originally about 800 ft. long. It was never permanently lined, and has given much trouble, a succession of slides having shortened it at each end. The new tunnel will be approximately parallel to the old, a maximum of 42 ft. lower as to grade, and just far enough south of it to keep the edges of the new approach cuts away from the ends of the ties of the existing track. The west and east approach cuts are 3000 and 1000 ft. long respectively, and are 50 ft. deep. Owing to the treacherous nature of the shale and the trouble that the old tunnel has given, it is not known just how long the new one will be made, nor what special precautions will have to be taken on account of the unequal pressure owing to the proximity of the old tunnel and the instability of the material.

The grading for the new construction, including Irvine yard, between Irvine and Beattyville is being done by the Carter Construction Company, of New York. The intervening work of filling bridges is being handled by Messrs. Hodges & Mimms, of Birmingham, Ala. The Mason & Hanger Company, of Lexington, Ky., is the general contractor for the work between Beattyville and Athol. The Luck Construction Company, of Roanoke, Va., has a subcontract for the grading from Beattyville to the North Fork, and also for ½ mile east of the Middle Fork. Between the two forks Mr. J. C. Williams, subcontractor, of St. Helens, Ky., is doing all grading except that of the Tyler tunnel and the short stretch from there east, which is being done by Mason, Hanger & Embry, of Tallega, Ky. The Mason & Hanger Company is handling the balance of the grading from Tallega to Athol, including the Mud tunnel, with its own forces. The Wardrup Construction Company, of Knoxville, Tenn., has the concrete work in the vicinity of Beattyville, including the culverts mentioned, the abutments and piers for the North Fork bridge, and all other concrete work east to the Tyler tunnel. From this point east Messrs. Shore & Hall are placing the concrete.

Mr. John Howe Peyton, chief engineer of construction of the Louisville & Nashville Railroad, has general charge of the construction work, and Mr. W. H. Courtenay, chief engineer, of the designing. Mr. E. L. Trowbridge, assistant engineer of construction, has more direct charge of the yard work at Irvine, Mr. W. A. Brownfield being resident engineer. The remainder of the work is under the direct charge of Mr. E. D. Sloan, assistant engineer. Mr. S. F. Ferguson is resident engineer for all changes from Irvine yard to Maloney, and Mr. L. B. Applegate is resident engineer for the remainder of the work.

New York State Highway Department Bridges

Standard Types and Details of Steel Girder and Truss Spans for Suburban Traffic

Uniform types and standard details of steel superstructures for highway bridges varying by small increments from 10 to 150-ft. spans have been prepared by the Department of Highways of the State of New York for the free use of town and county officials. The annual cost of highway bridge repairs in New York State is about $365,000, exclusive of the cost of new construction. In order to reduce this expense and to secure suitable, efficient and economical new structures, the highway law gives to towns and counties the privilege of securing plans, specifications, estimates and general advice and information for new bridges. Although this practice is not mandatory it is now used in about 75 per cent of all new jobs costing over $1500 each.

This effects an estimated saving of $200,000 a year, besides securing a much superior class of structures, about 33 per cent of which are provided with shop and mill inspection. Formerly bids were invited and all bidders presented unrestricted independent designs and specifications, often varying so much that no proper comparison could be made between them and affording an opportunity for the best talker to secure the contract, irrespective of merit. Under the new system bids are made on the same standard designs and requirements, and efficient construction is assured if the specifications are complied with.

The commission endeavors to secure permanent concrete protection for culvert beams, and concrete floors wherever practicable for longer spans. A book of instructions is issued giving tables of dimensions, materials and quantities for beam spans and a few important suggestions and typical drawings for truss spans. Bridges up to 150-ft. span are designed for a 16-ft. clear roadway and with capacity for a live-load of 85 lb. per square foot plus a concentrated load from a road roller, and vary in the type of floor and the provision for a 10-ton or a 15-ton roller.

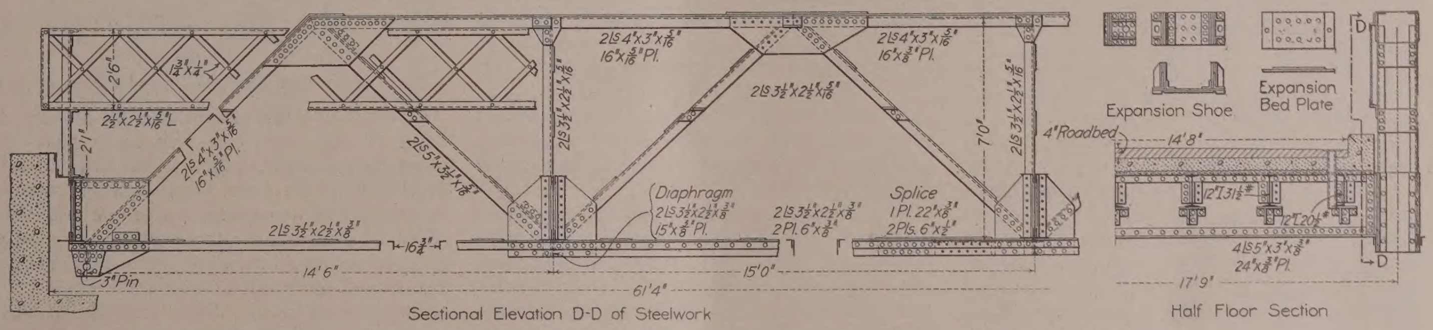
With a wooden floor proportioned for a 10-ton roller the cost and the steel weight per linear foot are estimated approximately as follows: For 50-ft. spans, $24 and 500 lb.; for 75 to 125-ft. spans, $30 and 618 lb.; for 150-ft. spans, $37 and 833 lb. With concrete floors and a capacity for 15-ton road-rollers the estimates are: For a 75-ft. span, $28 and 688 lb.; for a 125-ft. span, $37 and 818 lb.; for a 150-ft. span, $42 and 1017 lb. These estimates are exclusive of the cost of substructure and are for localities near railroad stations on through lines where the hauling cost is light.

The standard plans include girder spans varying in length by differences of 1 ft. from 10 to 30 ft. in the clear and varying by 5-ft. increments from 30 to 50 ft. and having capacities for 10-ton, 13-ton, and 15-ton rollers with roadways 16 and 18 ft. in width.

Up to 30 ft. in length the spans are called culverts and have pile foundations and paved waterways where necessary. They are of two types with protected and unprotected beams, the former having depths of 12, 15, 18 and 20 in. In all of these spans there are no I-beams except longitudinal girders, which directly support the solid concrete floor and the direct flange bearing on the abutment without sole plates.

In the longer spans up to 50 ft. there are in each a pair of unprotected deep longitudinal I-beam through girders with protected transverse floor beam I-beams riveted to their webs through hitch angles. The main girders are, for the 35-ft. span, 28-in. 105-lb. I-beams; for the 40-ft. span, 30-in. 120-lb. I-beams; for the 45-ft. span, 26-in. 10[illegible]-lb. I-beams; and for the 150-ft. span, 30-in. 180-lb. I-beams. The floor is uniform throughout and consists of concrete arches 6 in. thick at the crown seated on the bottom flanges of floor beams about 3 ft. apart on centers.

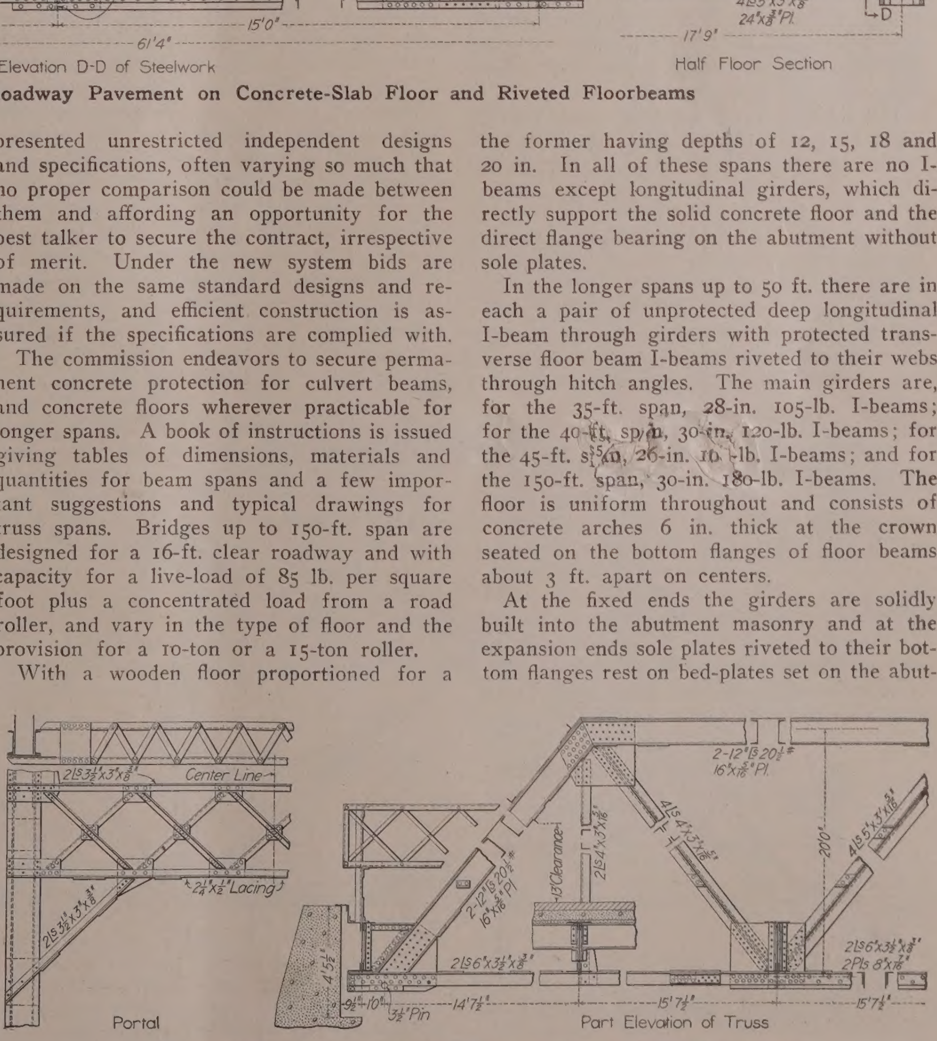
At the fixed ends the girders are solidly built into the abutment masonry and at the expansion ends sole plates riveted to their bottom flanges rest on bed-plates set on the abut-



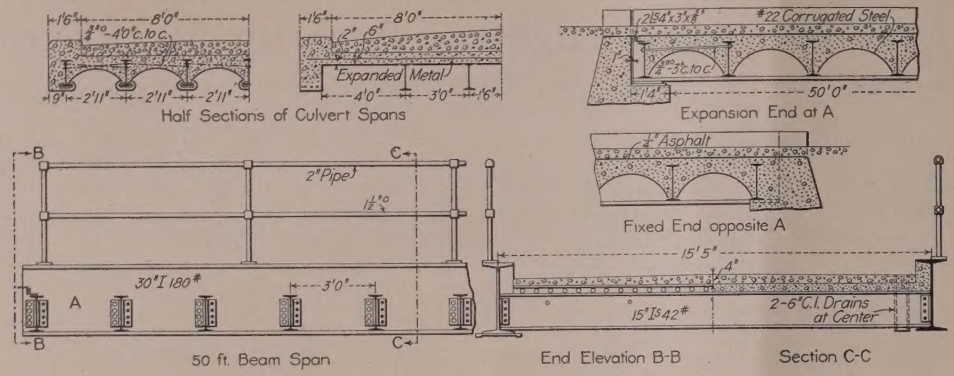
Sectional Elevation D-D of Steelwork

Half Floor Section

Pony-Truss Span with Roadway Pavement on Concrete-Slab Floor and Riveted Floorbeams



Through-Truss Span with Slab Floor on Plate-Girder Floorbeams



Short I-Beam Spans with Jack Arch or Reinforced-Concrete Arch Floors

ments. The bed-plates have plain tops without guide ribs, but are engaged between guides formed on the longitudinal edges of the solid sole plates. A short transverse angle riveted to the lower surface of the bed-plate projects into the concrete masonry and fixes the plate in position.

Truss Spans

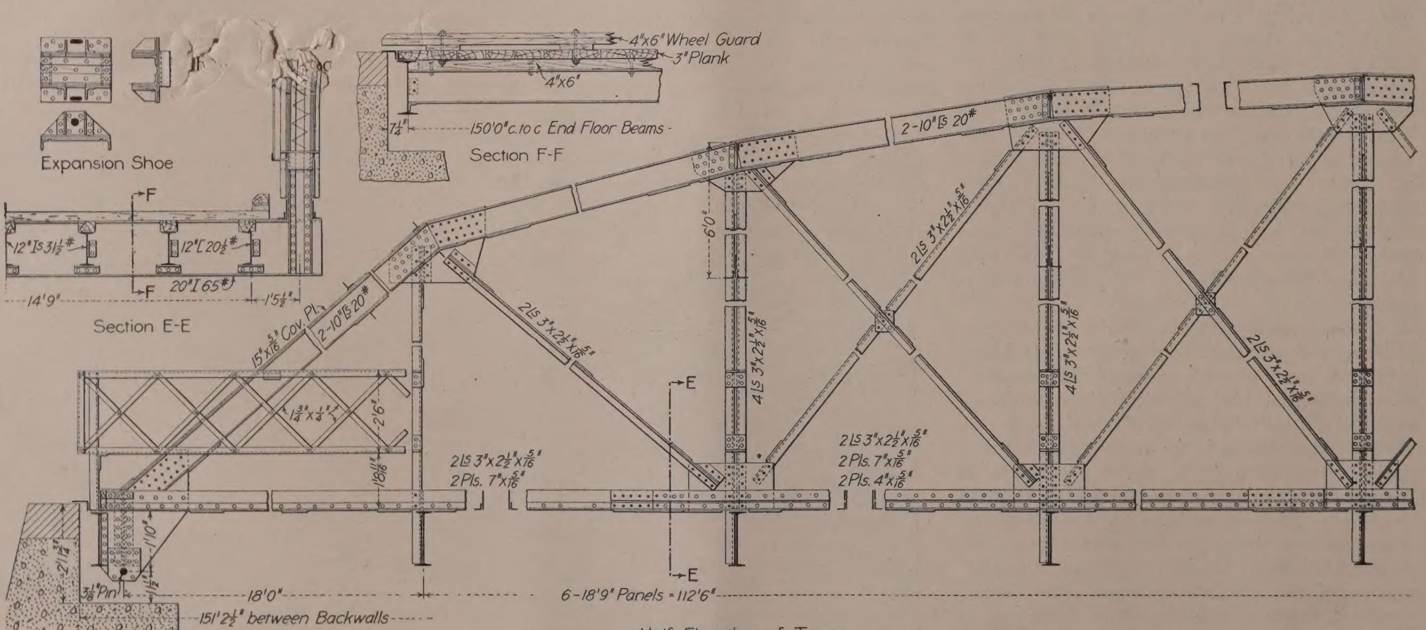
Spans of 60 ft. have riveted pony trusses 7 ft. deep, with all members made of pairs of angles connected by cover-plates or tie-plates. The top chords and end posts have cover-plates and the webs of the bottom chord angles are reinforced in the center panels by vertical plates. The gusset plates at lower chord panel points are made very large to serve as connections to receive the field riveted hitch angle connections of the 24-in. plate girder floor beams. At the ends of the lower chords the gusset plates project beyond the bottom flanges and are reinforced for pin-bearings in riveted shoes. The 6-in. reinforced concrete floor slab rests on the top flanges of steel stringers web connected to the floor beams and is integral with the curbs.

The laterals have T-shaped cross-sections made of pairs of small angles back to back riveted to connection plates on the bottom flanges of the lower chords. As they are several inches clear of the bottom flanges of the stringers they are connected to the latter by slotted plates engaging them and riveted between the backs of the angles. One of these plates is shop-riveted and the other is field-riveted to enable the connections to be made in erecting the bridge. The hand rails consist of very light lattice girders 30 in. deep seated on angle brackets riveted to the inner faces of the web members of the trusses.

The 125-ft. span with an 18-ft. roadway and a capacity for a 15-ton roller is of the same general type as the pony spans except for the cross-sections of the truss members and for the addition of a top lateral system. The top chords and end posts have regular trough-shape cross-sections made of two channels and a cover plate, and the inclined web members have I-shape cross-sections made of pairs of angles with latticed webs. The transverse struts and the X-braces between the top chords are made of pairs of angles connected by latticing in vertical planes and are field-riveted to pairs of top-chord flange plates. The portal struts are light lattice girders about 4 ft. deep, with each chord made of a pair of flange angles field riveted across the inclined end posts.

The principal points of difference between the 150-ft. and the 125-ft. spans are that the latter have inclined top chords, vertical posts receiving floor beams below the bottom chords, roller bearings at expansion ends, and a plank floor on steel stringers. The top laterals are all pairs of 3½ x 2½ x 5/16-in. angles latticed, and the bottom laterals are pairs of 2½ x 2½ x 5/16-in. angles riveted together back to back. The portals are double lattice girders 4½ ft. deep with 3½ x 2½ x 5/16-in. angle diagonals. The top chord transverse struts are replaced by sway frames 6 ft. deep.

The designs were prepared under the direction of the commissioners, Mr. F. Percy Hooker, Mr. T. Warren Allen and Mr. Robert Earl, and Mr. Samuel Holmes, bridge engineer of the Department of Highways.



Through-Truss Span with Plank Floor on I-Beam Stringers and Roller Bearings at Expansion End

Underpinning a Stone Retaining Wall

The construction now in progress on Section 1 of the Lexington Avenue Subway in New York City involved the excavation of a trench about 24 ft. deep through sand on Church Street, where the ground water level was about 12 ft. below the surface of the commencement of the work. Trinity Churchyard has a frontage of 425 ft. on Church Street opposite the excavation and is at an elevation of 15 ft. above the pavement. The soil here is retained by a massive stone wall with gravity section and a footing about 2 ft. 6 in. below street level. The base of this wall is about 18 ft. from and parallel to the neat line of the subway structure.

The soil is so unstable that it was considered necessary to support the toe of the wall and provide against undermining and loss of material from the rear of the wall before commencing the subway excavation. This was accomplished by underpinning the wall with solid concrete carried down about 10 ft. to groundwater level and supported on cylindrical columns extending below subgrade and inclosed on the outer side by a line of permanent interlocking steel sheeting to prevent any displacement of the churchyard soil.

Driving Foundation Piles

Operations were commenced by sinking in front of the wall a line of 5 x 5-ft. pits 5 ft. apart in the clear, which were excavated to ground-water level and sheeted with horizontal boards. The center line of these pits was about 6 in. beyond the face of the wall, so that each pit projected 2 ft. under the wall footing, far enough to permit driving there one or two steel pipes 14 in. in diameter. These pipes were made of light riveted sections 2 ft. long, with telescope joints, driven to a final depth of 2 ft. below subgrade by a 500-lb. cylindrical drop hammer 3 ft. long.

The hammer was operated, without special bearings, between three vertical guide rods 5 ft. long, which were rigidly attached to a heavy wooden cap engaging the top of the pipe. The hammer was hoisted by a manila line carried through a snatch block suspended above the pile, and thence to the capstan head of an electric hoisting engine. The engineman tailed off the slack and released it to make about ten strokes per minute, thus driving the piles at a maximum rate of from 10 to 20 lin. ft. in one eight-hour shift. As the piles were driven the interior was excavated by a Hayward dwarf orange-peel bucket or by a sand auger operated by hand.

Interlocking steel-sheet piling was driven to below subgrade at the rear of the pipe to prevent the possibility of a flow of quicksand after the excavation was begun. The pipes and the bottoms of the pits were concreted and on them were built brick piers 3 ft. square, wedged up to bearing against the old wall footings to carry the weight of the latter. All of the space around the woodwork was concreted and grouted, after which the intermediate spaces between the pits were excavated, foundation piles driven in them, new piers built and the concreting and grouting repeated so as to form with the first work a continuous retaining wall supported on column foundation carried below subgrade to an elevation beyond the probability of disturbance.

The work was executed by Frederick L. Cranford, Inc., contractor for Section 1 of the subway, with the approval of the Public Service Commission, of which Mr. Alfred Craven is chief engineer; Mr. Robert Ridgeway, engineer of subway construction, and Mr. J. O. Shipman, division engineer.

Stream-Flow Formulæ and the Ohio Flood

A stream flow ranging from 325,000 to 390,000 sec.-ft., equivalent to a runoff of from 85 to 102 sec.-ft. per square mile of watershed, which was recorded at a point 1½ miles below Miamitown on the Great Miami River during the Ohio floods last March, has convinced Mr. John A. Hill, consulting engineer, of Cincinnati, that existing formulæ for calculating maximum strain discharge cannot be depended upon in such extreme cases as the one in question. In a paper delivered before the Ohio Medical Association on Sept. 3 he said that the channel at Miamitown is of good section, and several high-water marks were established by the farmers during the crest of the flood or immediately after it had passed. Sections and slopes were carefully measured early last July and the condition of the channel noted, and from these data it was calculated that during the height of the flood a volume of water ranged between the amounts given above. This is an enormous volume for the drainage area, but it is justified by the rainfall records of twelve gaging stations well distributed on the watershed above Miamitown and by an estimate of the probable runoff from these records. A calculation of the discharge from these rain gagings gives 400,000 sec.-ft.

FORMULÆ AND STREAM DISCHARGE

Formula		Sec.-ft.
Rain gagings		400,000
Kutter	Maximum	390,000
	Minimum	325,000
	Mean	357,500
Dicken		240,050
Dredge		225,680
Fanning		192,000
Fossetti		176,872
Craig		145,886
Kuichling		143,868
Bürkli-Ziegler		143,294
Italian engineers' formula		111.587
Murphy (U. S. Geological Survey)		100,171
Cramer		98,750
Ganguillett (Swiss streams)		83,404

Comparing the results of various formulæ applied to the watershed above Miamitown with the probable flood flow based on the rain gagings it will be observed that only the Kutter formula approximates this discharge.

The table demonstrates that no formula would have predicted the flood of last March, as close study of flood conditions in this country has been limited to the last few years. Swiss, Italian, German and Russian engineers have for many years studied the subject in relation to their own rivers and watersheds, but their rules for flood discharge apparently will not fit the flood conditions in Ohio or possibly elsewhere in this country.

Coast Range Tunnel Holed Through

The tunnel through the Coast Range at Noti, Ore., on the Willamette Pacific Line between Eugene and Coos Bay, was holed through on Aug. 27 and 400 tunnel workmen in the camps of Twohy Brothers, railroad contractors, ate chicken dinners in celebration of the event. The tunnel is 2480 ft. long and the headings were advanced a little over 300 ft. in the twenty-seven days prior to the meeting. Work has been in progress for the last year and a half, and it is estimated that a month more will be required to complete the tunnel.

Book Reviews

"Builders' Quantities" is the subject of a book by William Edgar Ballard, Assoc. M. Inst. C. E., lecturer on building construction and quantities, City of Birmingham Municipal Technical School, the book being one of the "Longmans' Technical Handicraft Series." There are 123 pages, with fourteen chapters. The first chapter is introductory and the second defines the abbreviations of trade terms and mensuration used. The third and fourth chapters give respectively an order of taking off for the various trades, an enumeration of probable conditions and provisions, and the remaining chapters are devoted to the different classes of workers interested—the excavator, bricklayer, mason, slater and tiler, carpenter and joiner, ironmonger, smith and founderer, plasterer, plumber, and painter, paperhanger and glazier. The book uses the English units and nomenclature, and will probably be more useful to English than to American builders. (London, New York, Bombay and Calcutta, Longmans, Green & Company. 90 cents net.)

The National Fire Protection Association has issued new editions of the "National Electrical Code" and of suggestions of the Board of Underwriters for protection against lightning. The former embodies the rules and requirements of the National Board of Underwriters for electric wiring and apparatus. Both pamphlets are of pocket size, the code comprising 205 pages and the one on protection against lightning 10 pages. Both should be of value to engineers engaged in building and industrial-plant work. (Boston, National Fire Protection Association.)

STRUCTURAL DESIGN. Volume 1—Elements of Structural Design. By Horace R. Thayer, Assistant Professor of Structural Design, Carnegie Technical Schools. Cloth, 6 x 9; 221 pages; 69 figures. New York, D. Van Nostrand Company. $2 net.

(Reviewed by Frank H. Constant, Professor of Structural Engineering, University of Minnesota.)

The author states in the preface that the work is to form the first volume of a trilogy, the second and third parts of which will cover respectively the design of simple structures, such as plate girders, viaducts, truss bridges, mill and office buildings and standpipes, and the design of the so-called higher structures, such as cantilever, movable and suspension bridges, and arches. The present volume covers wooden structures and the elementary principles of design in steel. It presupposes a knowledge of mechanics, stresses and the dependent mathematics. It is divided into five chapters. Chapters 1 and 2 include a brief mention of the properties and characteristics of structural timber, cast iron and steel, wrought iron, steel and its alloys, and paint, and a description of the common steel shapes usually found in the handbooks. Chapter 3 covers wooden structures, including roof trusses, trussed beams, Howe trusses and trestle bents. Methods of proportioning members and joints are briefly given and numerical examples are worked out for each type. The treatment of the trussed beam presupposes a knowledge of the theory of indeterminate structures and of least work; otherwise the methods are elementary, simple and direct.

Chapters 4 and 5, constituting nearly two-thirds of the book, are devoted to the methods of bridge-company organization and production. In the former the author gives a description of the various component shops and the several steps in the fabrication and erection of the work. Chapter 5 covers the engineering department of the bridge company and some of the problems of design. A brief structural specification is given, a few economical relationships for span and panel lengths, and depth of truss are worked out algebraically (which, as is usual in all such developments, are of doubtful value), and the fundamental principles for the design of beams, girders, tension and compression members are briefly presented and illustrated by numerical examples.

The methods of detailing and of making, marking and checking shop drawings are satisfactorily treated, and this part of the book will prove helpful to beginning shop draftsmen and students engaged in similar work. Structural shop drafting as a distinct and important art has not received sufficient recognition in technical literature, and this book is intended primarily as a reference work along this line. It is almost wholly descriptive and as a general book upon structural design is open to the criticism of trying to cover too much ground, and inadequately. It is to be hoped that the author, in the succeeding volumes, will recognize the immense amount of theory in all good practical designing and emphasize this important side of the subject.

PLANS OF GRAIN ELEVATORS. Third Edition. Cloth. 9 x 12; 412 pages; 1279 illustrations. Grain Dealers' Journal, Chicago. $5 net.

This volume is designed to assist grain dealers contemplating building new elevators or overhauling old ones in forming some definite idea as to the style of house best suited to their needs. Consideration is given to defective and inferior construction and design and some of the difficulties met with by builders are recounted.

The illustrations are well selected and consist of photographs and drawings. Designers of grain elevators and storehouses will find valuable hints in this volume.

IRRIGATION: ITS PRINCIPLES AND PRACTICE AS A BRANCH OF ENGINEERING. By Sir Hanbury Brown. Cloth, 6 x 9: 301 pages; 77 illustrations. New York, D. Van Nostrand Company. $5 net.

The author has had an extensive experience in the design and construction of irrigation works in Egypt and India and is well qualified to discuss the principles and practice of irrigation engineering. The preface states that "this work attempts to set forth the guiding principles that should govern the practice of irrigation and to furnish illustration of their application in existing canal systems."

As would be expected, the illustrations and examples have been mostly drawn from irrigation works in India and Egypt.

The value and effects of irrigation are discussed in the first chapter. In Chapter 2, entitled "Basin System," basins and inundation canals are treated in detail. The perennial system of irrigation is described in Chapter 3, which also includes a brief discussion of the "duty" of water. The various sources of supply, with methods used in storing water, are discussed in Chapter 4. Chapter 5 treats in a thorough manner of the principles of design of reservoirs and the different types of dams. Methods of drawing the supply into the reservoir are described in Chapter 6. In Chapter 7, "Methods of Construction," the methods of sinking foundations in water are gone into. This chapter is very instructive for American engineers. Means of distribution are discussed in Chapter 8 and masonry works on irrigation canals are described in Chapter 9. Interesting and valuable data on the administration of irrigation systems are given in Chapter 10.

Chapter 11 is devoted to the control of the banks of canals and streams. Chapter 12, "Agricultural Operations and Reclamation Works," contains interesting hints on the use of water for irrigation purposes. Chapter 13 deals of irrigation canals as a means for navigation.

The book is well written, in an entertaining and pleasing style. The presswork, paper and binding are excellent, but the line drawings are badly executed and are not in keeping with the remainder of the book. The book not only covers the practice of irrigation as carried on in India and Egypt but contains a large amount of valuable information on the practice of irrigation and should find a place in the library of every irrigation engineer.

Letters to the Editor

Maps and Profiles for Federal Valuation of Railroads

Dear Sir: With reference to the tentative draft of specifications for maps and profiles for the Federal valuation of the railroads submitted by the Interstate Commerce Commission, and the objections of the railroads thereto, as outlined in your issue of Sept. 13, any civil engineer who has worked a considerable length of time in railroad work knows that some maps on all railways systems and a large number of maps on some railways are in a deplorable condition as regards up-to-date information. Bearing this in mind, a superficial glance into the specifications concerning maps would apparently justify their demands. There are, however, no two cases where conditions are exactly parallel, and while in some cases the specifications as outlined might be just the thing required, in other cases rigid adherence to specified standards would cause unnecessary duplication, which would result in an enormous and needless expense of both time and money.

In requiring the railroads to furnish original tracings to the Government, the commission is exacting more than the roads allow their own valuation departments. It has been the writer's experience, even where a railway system maintains a well-organized and systematized valuation department, that the department is not furnished with tracings except in rare cases. Cloth blueprints are furnished and these are corrected and kept up to date by means of colored inks, the corrections being obtained either by the agents of the department or received in blueprint or other form from the various offices of the system. This method, together with a negative enabling the Government to obtain as many prints as desired, should be sufficient for the needs of the commission. As suggested in the Engineering Record, the various standard requirements could be met where new maps are necessary.

There is no doubt that the specifications regarding right-of-way maps would produce ideal results as far as the Government is concerned, but it seems unjust that a railroad should be required to furnish such an enormous amount of information concerning property that is entirely outside of its physical boundaries.

The matter of profiles requires special attention. Copies or prints of the original profiles of the older lines are extremely rare, and even corrected profiles (due to change of alignment or grade) of our more recent lines are difficult to obtain. The original ground line in large cities, where the land adjacent to the railway property has been worked and improved, is obtainable only from profiles, and trouble encountered in obtaining these intensifies the difficulties of appraising one of the largest items, grading, which constitutes about 14 per cent of the entire physical valuation of an ordinary railroad in the Middle Western States. From these facts it appears that the Interstate Commerce Commission is justified, to a large extent, in demanding new and up-to-date profiles. Where available, however, old profiles that are corrected to date and show the desired information should be acceptable to the commission regardless of whether they meet requirements as to size, scale used, direction of stationing and type of lettering.

Chicago. Claude L. Van Auken.

Corrections in British Columbia Dredging Data

Dear Sir: Referring to data given in the Engineering Record of Aug. 23, page 209, dealing with the performance of Dominion Government dredges in British Columbia, I wish to draw your attention to two errors.

The first error is on page 197 in the article entitled "Reference Data on Dredges." You state that the British Columbia dredging fleet is still under my active direction. This is not the case; I left the service about nine months ago.

The other error is in Table 2, on page 210. The total cost of operation of the dredge "Fruhling" was $92,552, instead of $12,552. I think this error must be a typographical one.

Vancouver, B. C. H. A. Bayfield.

Automatic Chemical Feeder

Dear Sir: In connection with the description of the chemical feeder printed on page 264 of the Engineering Record of Sept. 6, I wish to state that the results were not obtained with the use of a Venturi tube of the usual type, as one would readily infer from the sketch presented. Instead the constriction in the 6-in. main to which the chemical was added was obtained by inserting a stick of wood cut to the desired shape. A cylindrical stick, 4 ft. long and 6 in. in diameter, was cut and from this a piece, wedge shaped at both ends, was sawed. This piece was fastened inside the pipe with a single screw through a drill hole in the iron. The area of the full section was to the area of the reduced section approximately as 5 to 1.

Urbana, Ill. Ralph Hilscher.

Forfeiture of Contract Bond

Dear Sir: When a man breaks a contract of any description he thereby forfeits the faith of the party of the other part. I am not in a position to answer the query of Mr. Bader in the Engineering Record of Sept. 13, page 307, as regards public work, but I have been in touch with some experiences with contract work performed for corporations. I will cite an instance where an agreement was abandoned by the prospective contractor.

It was the desire of this corporation to have the old coal bunkers removed from what was once a small power plant, but which was then being converted into a substation for the distribution of electric energy. The work was of a difficult character, the steel bunkers being situated high above the boilers; the latter had already been removed. What made the work still more "ticklish" was the fact that two 1000-kw rotary converters had been installed on the floor beneath the bunkers. Thus the dropping of a bolt during the dismantling of the bunkers might wreck a $15,000 machine.

The contract was advertised and several estimates were received. The lowest bidder offered to do the work for $3000 plus the material. The corporation insisted that he put up a bond covering his estimate as an evidence of good faith, and he complied. A firm willing to furnish his bond was found. Then the contract was prepared.

In the meantime the contractor, who was not an American, began to lose nerve. He asserted that he was willing to perform the work but asked that the corporation first cancel his bond, as he did not feel that he should work under bond, considering the difficulty of the job.

The job was important and the corporation, anxious to have it completed, consented to assume all risks. However, as soon as the bond was canceled the contractor backed out entirely and the corporation had to find some one else to do the job for 50 per cent more money. The estimates of this contractor were never again considered upon any of the company's subsequent work for the reason that he is considered incompetent and untrustworthy.

As to the legality of such exclusion in the case of public work, it is dependent upon the laws of the State and the charter of the municipality. In general, however, no man can be excluded from estimating upon public work. The fact that he forfeited his bond on a previous contract should not stand against him, in a legal sense, because by requiring a bond the city, etc., admits the breakage of the contract legal, if compensated for by the payment of a certain sum of money. But while in general all should be allowed to bid who are able to put up the required bond, it is not necessary that the estimate of each bidder shall be considered. If, for any reason, a certain bidder should be thought to be unreliable, his estimate can be turned down.

The legal status of the situation in general may be summed up thus: Any citizen capable of performing a certain work has the right to submit an estimate covering said work. The lowest bid should be selected, unless, in the opinion of the board, council, etc., the contractor submitting such bid shall be held to be untrustworthy, and his work, therefore, derogatory to the welfare of the State.

Brooklyn, N. Y. W. F. Schaphorst.